CHAPTER 6

CONSTRUCTION EQUIPMENT POWER TRAINS

INTRODUCTION

Learning Objective: Identify the operational characteristics and components of drive trains, track assemblies, and track frames that are common to construction equipment power trains. Describe the operation of a winch. Identify the characteristics and maintenance of wire rope.

The construction equipment used by the Navy are equipped with power trains that are similar in many ways to the automotive vehicle power trains described in chapters 4 and 5. However, factors, such as size, weight, design, and use, of the construction equipment require power trains that vary greatly in configuration.

DRIVE TRAINS

Learning Objective: Identify the operational characteristics and components of construction equipment drive trams.

There are numerous types of equipment used in construction, from crawler tractors to excavators. However, the way power is distributed varies from piece to piece. The most common drive trains used in modern construction equipment are the mechanical and the hydrostatic drive trains.

MECHANICAL DRIVE TRAIN

The mechanical drive train found in construction equipment is similar to that of the automatic transmission in that a transmission is used in conjunction with a torque converter and shifting is accomplished hydraulically when the operator moves the range selector lever.

Power Shift Transmission

The power shift transmission (fig. 6-1) uses a torque converter and is designed to provide high-speed shifting through hydraulically actuated clutches. The transmission has two forward and two reverse speeds in both high and low ranges. The hi-lo shifting lever mounted on the transmission front cover controls shifting from one range to another.

NOTE

The principles of a torque converter are presented in chapter 4 of this TRAMAN.

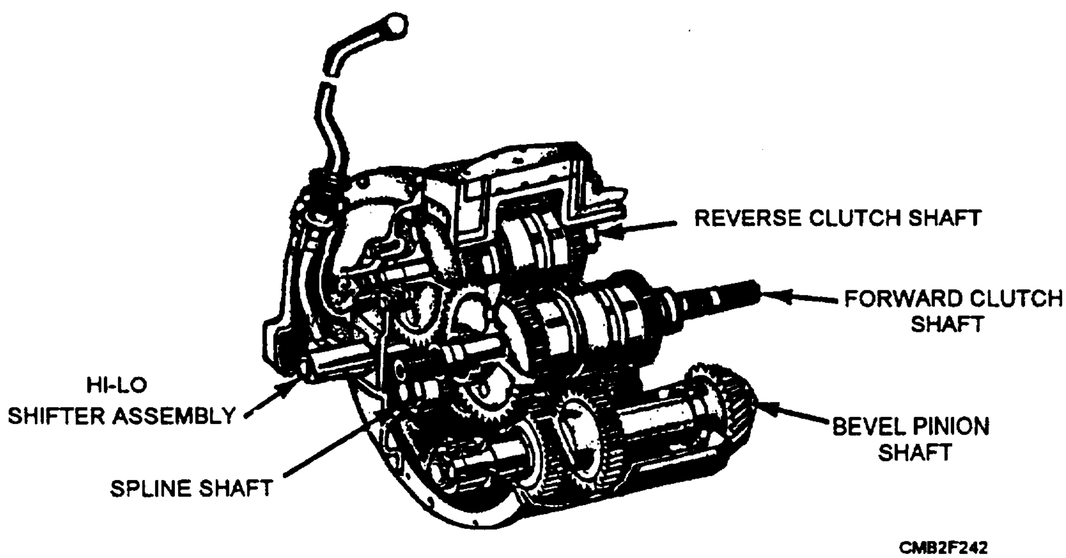


Figure 6-1.—Power shift transmission.

The power shift transmission is coupled to the torque converter by a universal joint. Gears are mounted in the power shift transmission on four shafts, which are as follows:

- The REVERSE CLUTCH SHAFT (fig. 6-2) has a straight roller bearing at each end, with the reverse driven gear keyed to the front of the shaft. The shaft consists of first and second speed drive gears riding on bushings and is welded to the dual hydraulic clutch pack assemblies.
- The FORWARD CLUTCH SHAFT (fig. 6-3) rotates on straight roller bearings at the rear and ball bearings at the front, with the reverse drive gear keyed to the front of the shaft. As with the reverse clutch shaft. the forward clutch shaft consists of first and second speed drive gears riding on bushings and is welded to the dual hydraulic clutch pack assemblies.

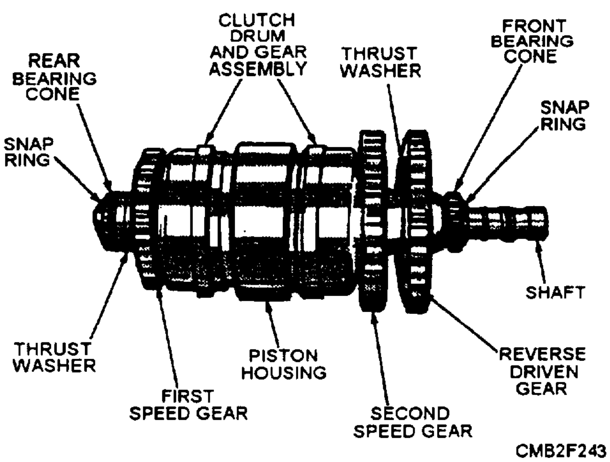


Figure 6-2.—Reverse clutch shaft.

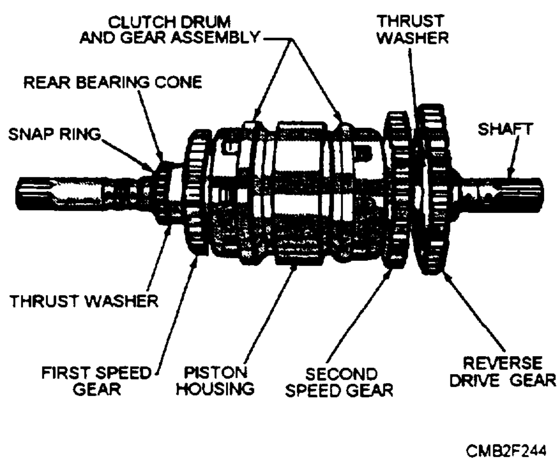


Figure 6-3.—Forward clutch shaft.

- The SPLINE SHAFT (fig. 6-4) rotates on two straight roller bearings. The rear bearing is mounted in the transmission case; the front bearing is mounted in the transmission cover. The first and second driven gears are held in position on the spindle by snap rings and are constantly meshed with the first and second speed drive gears on the clutch shafts. The hi-lo driving gear slides freely on the shaft and drives the bevel pinion shaft when brought into mesh with either the high or low range driven gear by means of the hi-lo shifting lever.
- The BEVEL PINION SHAFT (fig. 6-5) consists of the high and low range gears, which are keyed to the shaft. The shaft is supported at the rear by a straight roller bearing, and, at the front, by a double-row taper roller bearing. The pinion gear is splined to the rear of the pinion shaft and is held in place by a nut. A shim pack is provided between the front bearing cage and the transmission case front cover for adjusting pinion depth.

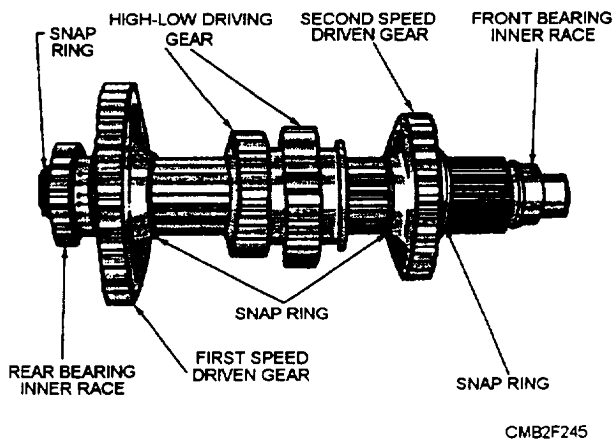


Figure 6-4.—Spline shaft.

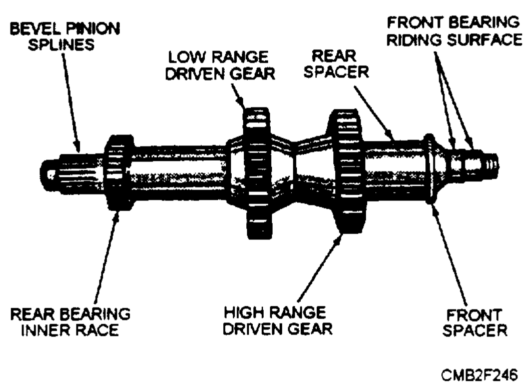


Figure 6-5.—Bevel pinion shaft.

FORWARD AND REVERSE HYDRAULIC CLUTCH OPERATION.—The forward and reverse hydraulic clutches actually have two clutches on a common shaft with a common apply force piston between them. The clutches allow the simple transfer of oil from the disengaging clutch into a cavity created by the engaging clutch. This allows a low volume of main pressure to actuate the clutch for high-speed shifting.

The heart of the clutch is contained in two pistons—the accelerator piston and the force piston. Pump oil volume is not needed to fill the applying clutch cavity, and only relatively low volume is needed to pressurize the clutch. In neutral, all accelerator and force piston cavities are filled with oil at lube pressure (10 to 25 psi). A selector valve, located on the top of the transmission case, directs the oil to the accelerator piston cavity and, in turn, to the force piston cavity. Once the pistons are filled with oil, they remain full under lube pressure. Other small cross-drilled passages furnish a constant supply of lube oil to the drive gear bushing, the drum assemblies, and the clutch hubs for distribution through the clutch plates. In neutral, neither clutch is engaged, the drive gear and drum assemblies are free. and no torque is transmitted through the clutch, as shown in figure 6-6.

Upon application of the clutch, main oil pressure (approximately 200 to 300 psi) is directed through the clutch shaft for the specific side of the clutch desired. The oil enters the force piston cavity causing the clutch to engage (fig. 6-7). When engaged, the clutch holds the gear stationary in relation to the shaft. Power then flows from the shaft, via the clutch, to the gear.

When the transmission is returned to neutral, an immediate pressure drop occurs within the disengaging accelerator piston cavity and the compressed piston centering springs return the common apply force piston to its centered position or neutral.

GEAR SHIFTER MECHANISM.—On many older models, the gearshift lever is connected through

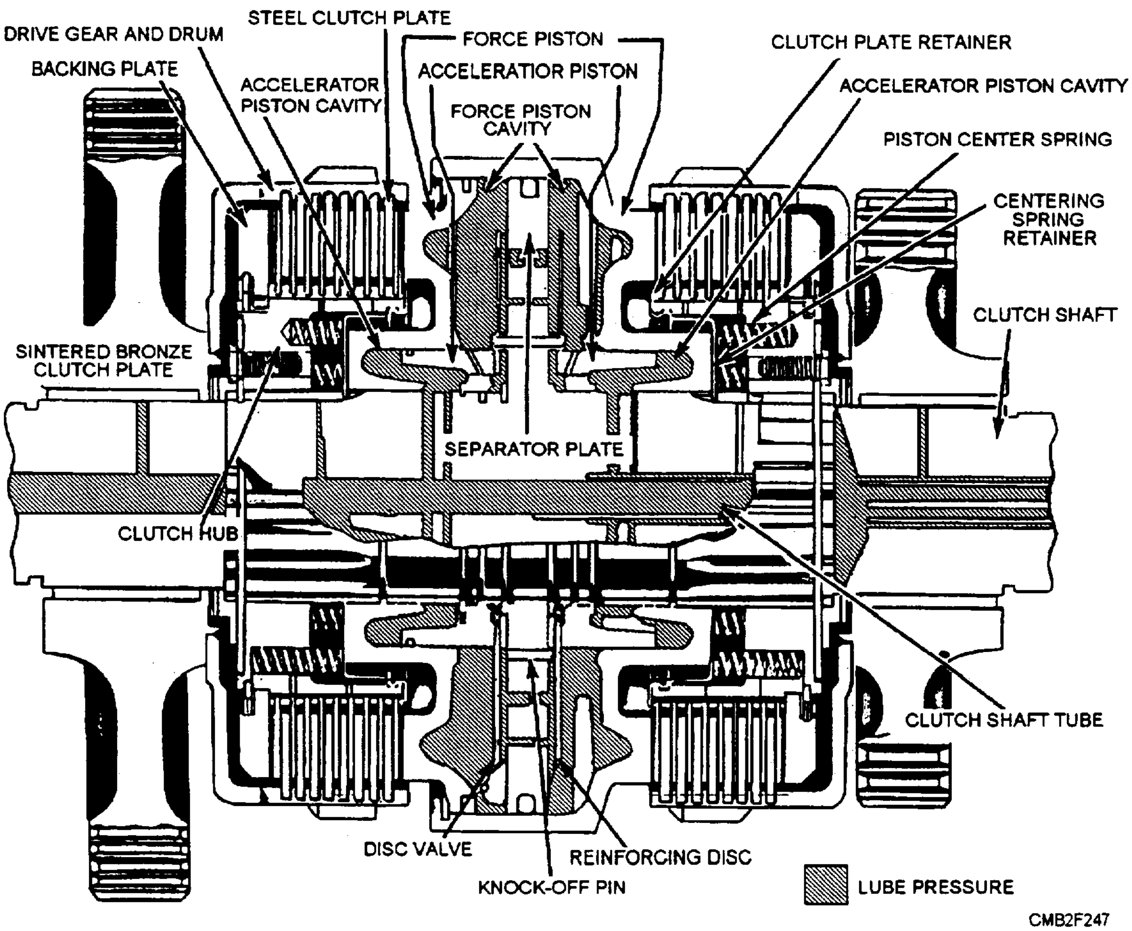


Figure 6-6.—Flow of oil through the clutch in NEUTRAL position.

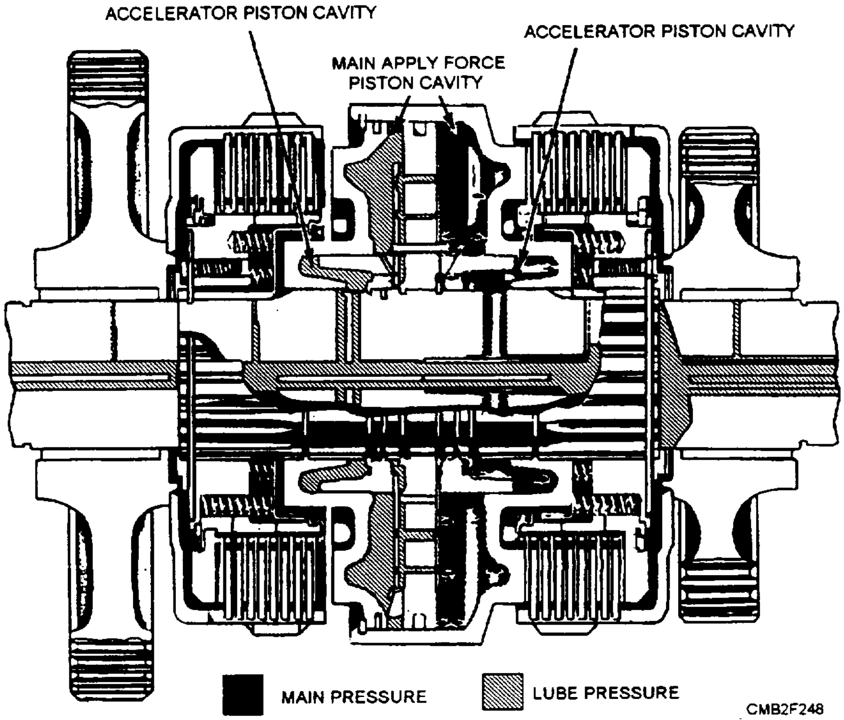


Figure 6-7.—Flow of oil through the clutch in ENGAGED position.

linkage to the range selector valve assembly on top of the transmission case. Movement of the gearshift lever positions the selector valve to allow main oil pressure to engage the desired clutch assembly.

In modern power shift transmissions, the gearshift lever is connected to a range selector valve by hydraulic means. A spool valve (pilot control valve), actuated by the gearshift lever, directs main oil pressure to the range selector valve and causes it to direct main oil pressure to the desired clutch assembly.

The hi-lo-shifting lever (on the transmission front cover) is held in position by a poppet lock in the hi-lo shifting housing. To shift from one range to another, the engine must be running and the gearshift lever must be in NEUTRAL position. This allows main oil pressure from the pump to pass through a drilled hole in the pilot valve and through an oil line to the shifter housing. Here it releases the poppet lock to enable shifting.

Planetary Gearsets

Some power shift transmissions use planetary gearsets to perform the same functions as the transmission just described. A planetary gearset (fig. 6-8) consist of three members—sun gear, ring gear, and a planetary carrier that holds the planetary gears in proper relation with the sun and ring gear. The planetary gears are free to "walk" around the sun gear or inside the ring gear.

To cause a reduction or increase in torque, six different methods of connecting this gearset to the power train are possible (fig. 6-9). Direct drive is achieved by locking any two members together. and neutral is obtained by allowing all the gears to turn freely.

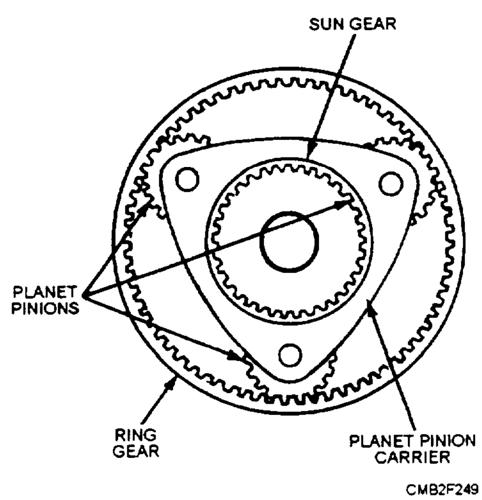


Figure 6-8.—Planetary gearset.

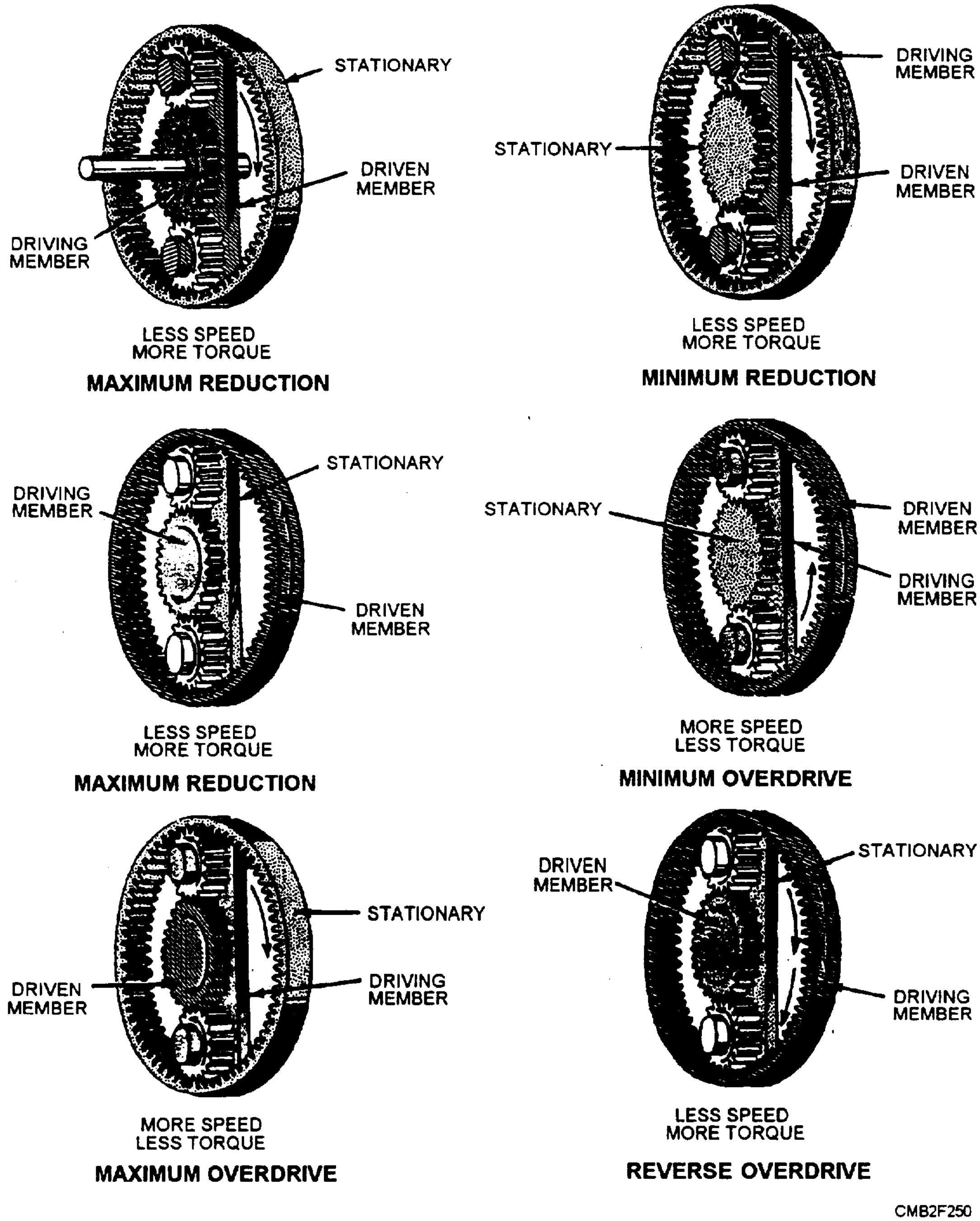


Figure 6-9.—Planetary gear arrangements that will provide an increase or decrease in speed.

In figure 6-9 notice the direction of rotation as power is applied to the various members and others are stationary. In actual application, planetary gearsets are used as single or multiple units, depending on the number of speed (gear) ranges desired.

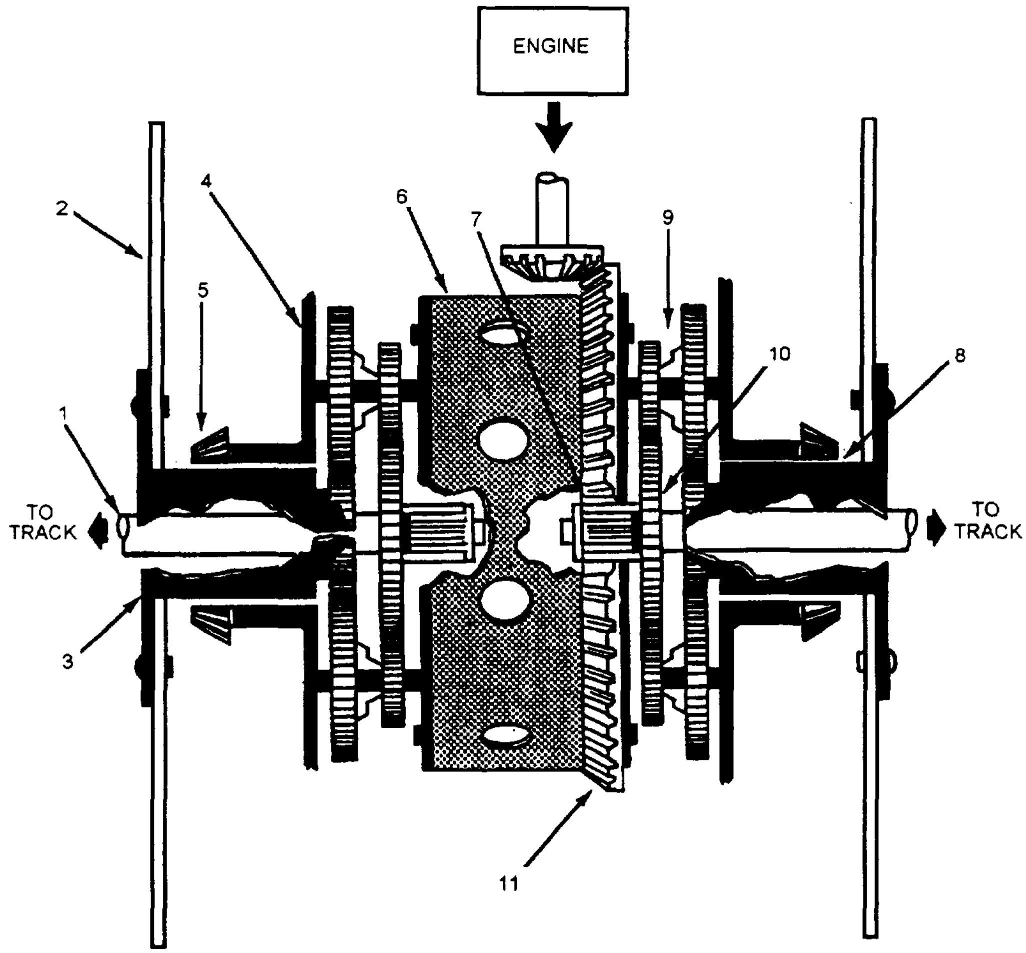
On tracked equipment, power for turning the drive sprockets may flow through a planetary gear arrangement that provides maximum reduction (fig. 6-9). The sun gear forces the planetary gears to revolve in the stationary ring gear and move the carrier in the same direction of rotation as the sun gear. The carrier is connected to the hub on which the sprocket is mounted, causing it to rotate with the carrier. This arrangement produces the maximum torque and speed reduction obtainable from a planetary gearset.

Planetary Steering

Some tracked equipment may be steered by a system that combines planetary steering and pivot brakes. The planetary steering system (fig. 6-10) differs from the one previously described in that the planetary pinion gears are two gears of different sizes, machined into one piece. Two sun gears are also included. One sun gear is splined to the sprocket pinion shaft, and the other is machined on the steering brake hub. The sun gear, machined to the steering brake hub, performs the same function as the ring gear in a conventional planetary system. Bushings are used to isolate the sprocket drive shafts and the steering brake hubs from the bevel gear carrier and the planetary carrier. Lubrication is provided from the oil sump located below the assembly.

When the tracked equipment travels straight ahead, its steering brakes are held in the applied position by heavy coil springs. Braking prevents the steering brake hub and sun gear from rotating and forces the large planetary pinion gears to "walk" around the sun gear. Then power is transmitted to the sun gear on the sprocket drive shaft from the smaller planetary pinion gears.

When a gradual turn is being made, the operator moves one of the steering levers back far enough to release the steering brake on one end of the planetary system. When the brake is released, the planetary pinion gears stop "walking" around the sun gear on



1. SPROCKET DRIVE SHAFT
2. STEERING BRAKE DISK
3. STEERING BRAKE HUB AND SUN GEAR
4. PLANETARY CARRIER
5. PLANETARY CARRIER BEARING
6. BEVEL GEAR CARRIER
7. SPROCKET DRIVE SHAFT SUPPORT BUSHINGS
8. STEERING BRAKE SUPPORT BUSHINGS
9. PLANETARY GEARS
10. SPROCKET DRIVE SHAFT SUN GEAR
11. BEVEL GEAR

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Figure 6-10.—Planetary steering systems.

the steering brake hub. This hub then rotates with the planetary carrier, and no power is transmitted to the sprocket drive shaft.

Occasionally, an adjustment of the steering brake is required to prevent slippage when it is engaged. Consult the manufacturer's service manual for adjustment procedures.

Pivot Brakes

The pivot brakes on tracked equipment are of the multiple disc type. Pulling the steering brake levers fully to the rear operates them. The middle discs (splined to the sprocket drive shaft) have laminated linings. The intermediate discs (held in position by studs) are smooth steel discs. An actuating disc assembly is two steel plates with steel balls between them. The assembly is located in the center of the discs and is connected to the operating linkage.

Ramps are machined on the steel plate of the actuating disc assembly, so when the brakes are applied, the steel balls move up the ramps and force the plates apart. Movement of the plates causes the discs to be squeezed together and to stop rotation of the sprocket drive shaft. When these brakes are fully applied, the tracks will stop. The steering levers are linked to the brakes independently to actuate them for sharp turns.

Adjustment of the pivot brakes is required to provide adequate braking with the steering levers. An adjustment is required when the steering levers can be pulled against the seat with the engine running. Consult the manufacturer's service manual for proper adjustment procedures.

HYDROSTATIC DRIVE TRAIN

The hydrostatic drive is an automatic fluid drive that uses fluid under pressure to transmit engine power to the drive wheels or tracks.

Mechanical power from the engine is converted to hydraulic power by a pump-motor team. This power is then converted back to mechanical power for the drive wheels or tracks.

The pump-motor team is the heart of the hydrostatic drive system. Basically, the pump and motor are joined in a closed hydraulic loop; the return line from the motor is joined directly to the intake of the pump, rather than to the reservoir (fig. 6-11). A charge pump maintains system pressure, using supply oil from the reservoir.

The hydrostatic drive functions as both a clutch and transmission. The final gear train then can be simplified with the hydrostatic unit supplying infinite speed and torque ranges as well as reverses speeds.

To understand hydrostatic drive, you must understand two principles of hydraulics:

- Liquids have no shape of their own.
- Liquids are not compressible.

The basic hydrostatic principle is as follows (fig. 6-12):

- Two cylinders connected by a line both filled with oil. Each cylinder contains a piston.
- When a force is applied to one of the pistons, the piston moves against the oil. Since the oil will not compress, it acts as a solid connection and moves the other piston.

In a hydrostatic drive, several pistons are used to transmit power—one group in the PUMP sending power to another group. in the MOTOR. The pistons are in a cylinder block and revolve around a shaft. The pistons also move in and out of the block parallel to the shaft.

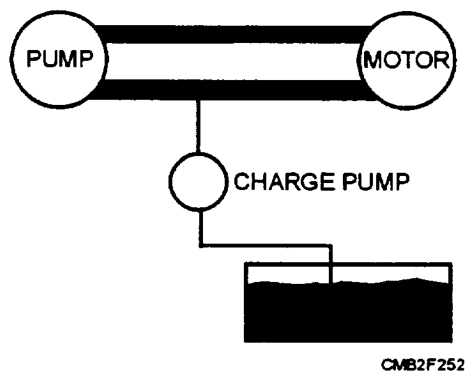

Figure 6-11.—Pump and motor form a closed hydraulic loop.

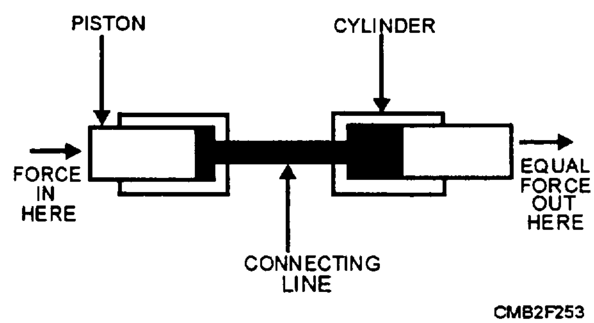

Figure 6-12.—Basic hydrostatic principle.

To provide a pumping action for the pistons, a plate, called a SWASH PLATE, is located in both the pump and motor (fig. 6-13). The pistons ride against the swash plates. The angle of the swash plates can be varied, so the volume and pressure of oil pumped by the pistons can be changed or direction of the oil reversed. A pump or motor with a movable swash plate is called a variable-displacement unit. A pump or motor with a fixed swash plate is called a fixed displacement unit. There are four pump-motor combinations, which are as follows (fig. 6-14):

- Fixed displacement pump driving a fixed displacement motor (fig. 6-14, view A). This setup will give you constant horsepower and torque at the output with a steady input speed. If input speed varied, horsepower and speed will vary but torque will remain constant. Because both the pump and motor are fixed displacement, this system is like a gear drive; it transmits power without altering the speed or horsepower between the engine and the load.

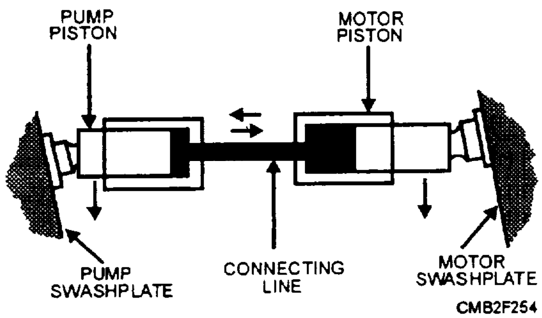

Figure 6-13.—Connected cylinders with swash plates.

- Variable displacement pump driving a fixed displacement motor (fig. 6-14, view B). Since the pump is variable, output speed is variable and torque output is constant for any given pressure. This setup provides variable speed and constant torque.
- Fixed displacement pump driving a variable displacement motor (fig. 6-14, view C). In this setup changing the motor displacement varies output speed. When motor displacement decreases, output speed increases, but output torque drops. When the setup is balanced, it gives a constant horsepower output.
- Variable displacement pump driving a variable displacement motor (fig. 6-14, view D). This setup gives an output of both constant torque and constant horsepower. It is the most flexible of all the setups, but it is also the most difficult to control.

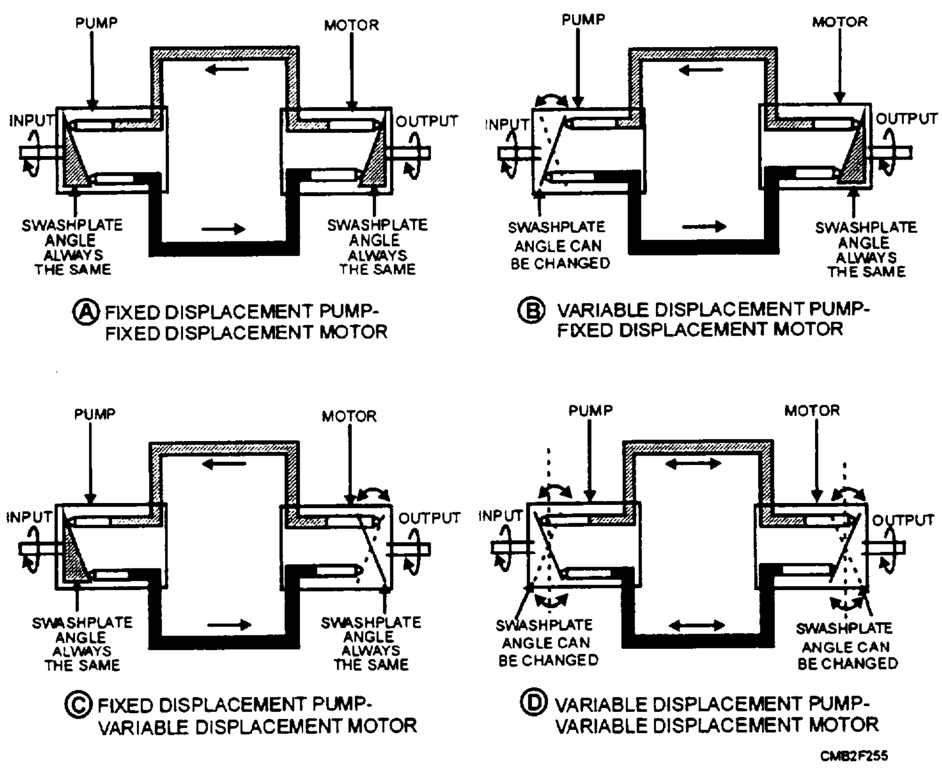

Figure 6-14.—Pump and motor combinations for hydrostatic drives.

The direction of output shaft rotation can be reversed in variable setups by shifting either the pump or the swash plate of the motor over center.

Remember three factors control the operation of a hydrostatic drive. These factors are as follows:

- RATE of oil flow—gives the speed
- DIRECTION of oil flow—gives the direction
- PRESSURE of the oil—gives the power

The pump is driven by the engine of the machine and is linked to the speed set by the operator. It pumps a constant stream of high-pressure oil to the motor. Since the motor is linked to the drive wheels or tracks of the machine, it gives the machine its travel speed.

The advantages ofhydrostatic drive are as follows:

- Infinite speeds and torque
- Easy one-lever control
- Smooth shifting
- Shifts "on the go"
- High torque available for starting up
- Flexible location—no drive lines
- Low maintenance and service
- Reduces shock loads
- Compact size
- Eliminates clutches and large gear trains

Hydrostatic Drive Operation

For you to understand how a hydrostatic drive operates, we will explain the operation of a typical system. The system we will use has an axial piston pump and motor which is the 'most common hydrostatic drive system. The pump has a variable displacement, while the motor has a fixed displacement. Now look at the complete system in operation—forward, neutral, and reverse.

FORWARD (fig. 6-15).—When the operator moves the speed control lever forward, the spool in the displacement control valve, also known as the FNR valve (Forward, Neutral, and Reverse), moves from its NEUTRAL position. This action allows pressure oil to flow into the upper servo cylinder forcing the swash

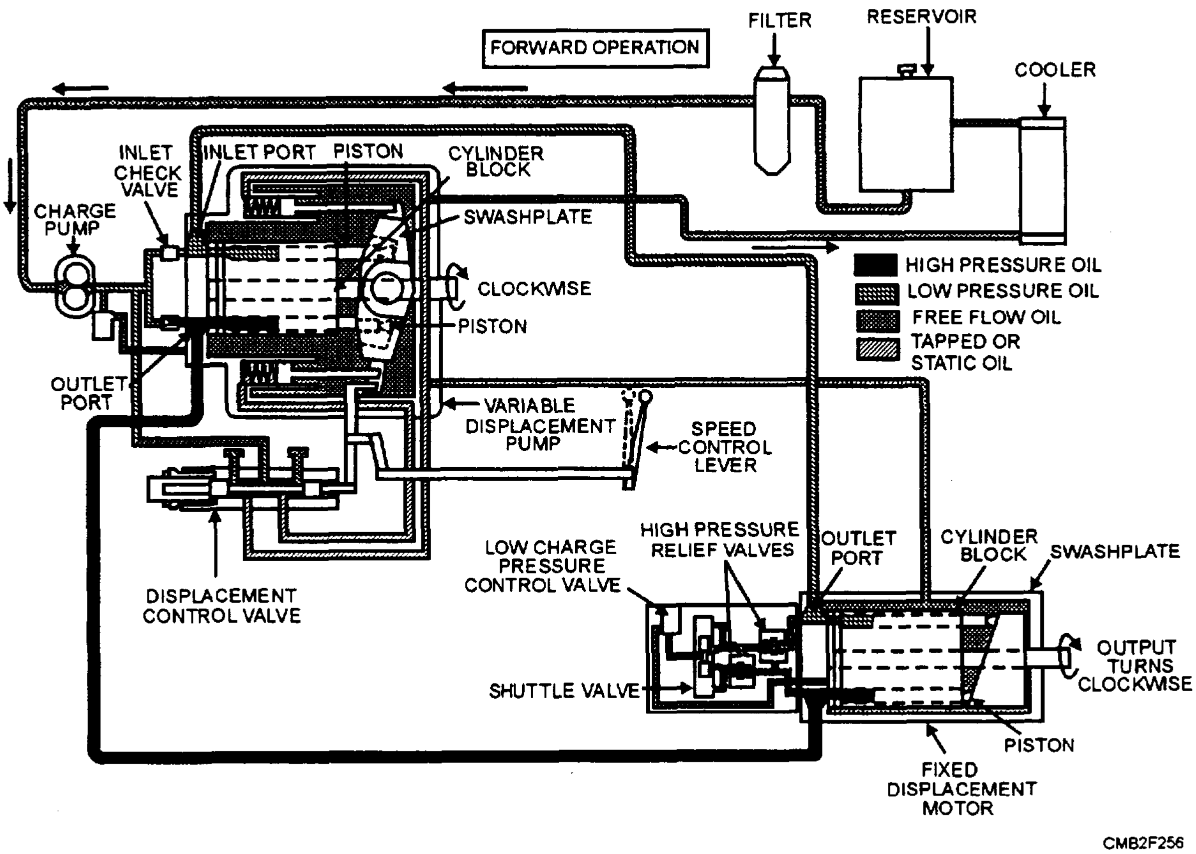

Figure 6-15.—Forward operation.

plate to tilt. Oil, expelled by the opposing servo cylinder. returns through the displacement control valve (FNR valve) to the pump case.

As the swash plate reaches the tilt set by the speed control lever, the displacement control valve (FNR valve) spool returns to a NEUTRAL position, trapping the oil to both servo cylinders and holds the swash plate in its titled position. The swash plate will remain titled until the operator moves the speed control lever.

With the pump drive shaft and cylinder block rotating clockwise and the swash plate is titled to the rear, it is now time to start pumping. As the cylinder rotates past the pump inlet port, the inlet check valve opens: oil is then forced by the charge pump into the piston bores that align with the inlet port under low charge pressure. As rotation continues, oil is forced out of the outlet port at high pressure by the pump pistons when they align with the outlet port. This flow of oil drives the motor.

The distance the pistons reciprocate in and out of the cylinder block depends on the angle of the swash plate of the pump. This determines the volume of oil displaced per revolution of the pump. The greater the angle, the greater the volume and the more oil flows from the pump. As the angle of the swash plate is varied so will the volume of oil displaced from the pump.

As pressure oil enters the inlet port of the motor, the pistons that align with the inlet port pushes against the swash plate. Since the fixed swash plate is always tilted, the pistons slide down the inclined surface and the resulting forces rotate the cylinder block. This, in turn. rotates the output shaft driving the machine forward.

As the cylinder block continues to rotate clockwise, oil is forced out the outlet port at low pressure and returns to the pump where it is recirculated through the pump and back to the motor.

This is called a “closed system” because the oil keeps circulating between the pump and the motor. The only extra oil comes from the charge pump that maintains a given flow of oil through the system whenever the machine is running.

A shuttle valve, located in the motor manifold and controlled by high oil pressure, prevents high oil pressure from entering the low-pressure side of the system. This action keeps the charge circuit open to the low-pressure valve while the system is running.

The high-pressure relief valve, located in the motor manifold, monitors the pressure of the forward flow of oil and protects the system from too high pressures. If pressure exceeds the rated psi, a relief valve opens and oil bypasses the cylinder block in the motor. This will either slow or stop the machine. The bypassed oil returns to the pump. This action continues until the load is reduced below the rated psi. Then the relief valve closes and oil again flows to the cylinder block, moving the machine forward.

NEUTRAL (fig. 6-16).—With the speed control lever in neutral, free oil flows from the reservoir through the oil filter to the charge pump. The charge pump pumps the oil past the high charge pressure control valve and into the main pump housing. The oil circulates through the housing and returns through the oil cooler and back to the reservoir.

Trapped oil is held in the cylinder block of the pump, in the motor, and in the connecting lines between the pump and motor by two check valves in the pump end cap.

When the control lever is in neutral, the swash plate in the pump is also in neutral and the pistons within the pump are not pumping. Therefore no oil is being moved to provide either forward or reverse motion.

The cylinder block in the pump rotates in a clockwise direction and is driven by the engine of the equipment. Rotation is viewed from the drive shaft end of the pump. Because the oil is not being pumped to the motor, the cylinder block in the motor is stationary and the output shaft does not move.

NOTE

With the drive system in neutral, the high charge pressure control valve, (located at the charge pump) controls pump pressure. When the system is activated for reverse or forward, the low charge pressure control valve located in the motor manifold controls the charge pressure at a lower psi.

REVERSE (fig. 6-17).—As the speed control valve is moved to reverse, the spool in the displacement control valve (FNR valve) moves out of neutral allowing pressure oil to flow into the lower servo cylinder, tilting the swash plate forward.

When the swash plate reaches its desired tilt, which is set by the control lever, the displacement control spool returns to neutral. This action traps the

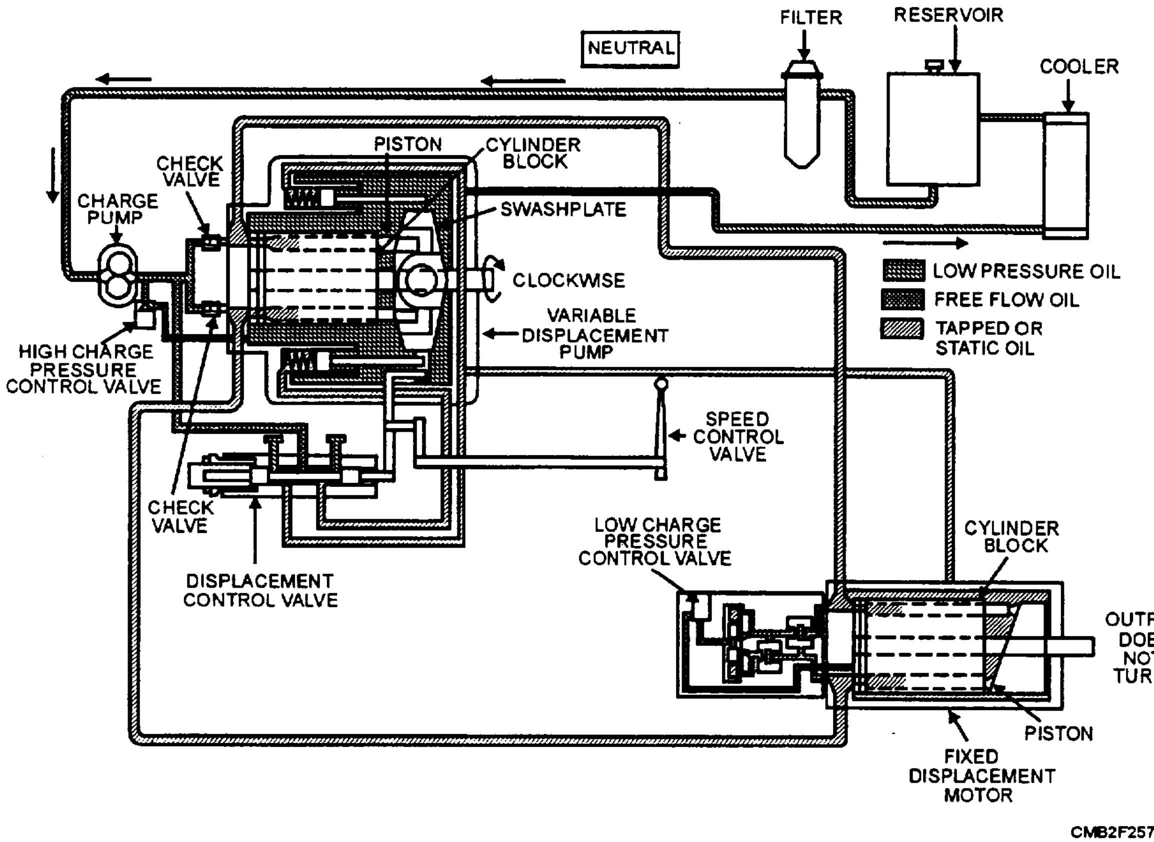

Figure 6-16.—Neutral operation.

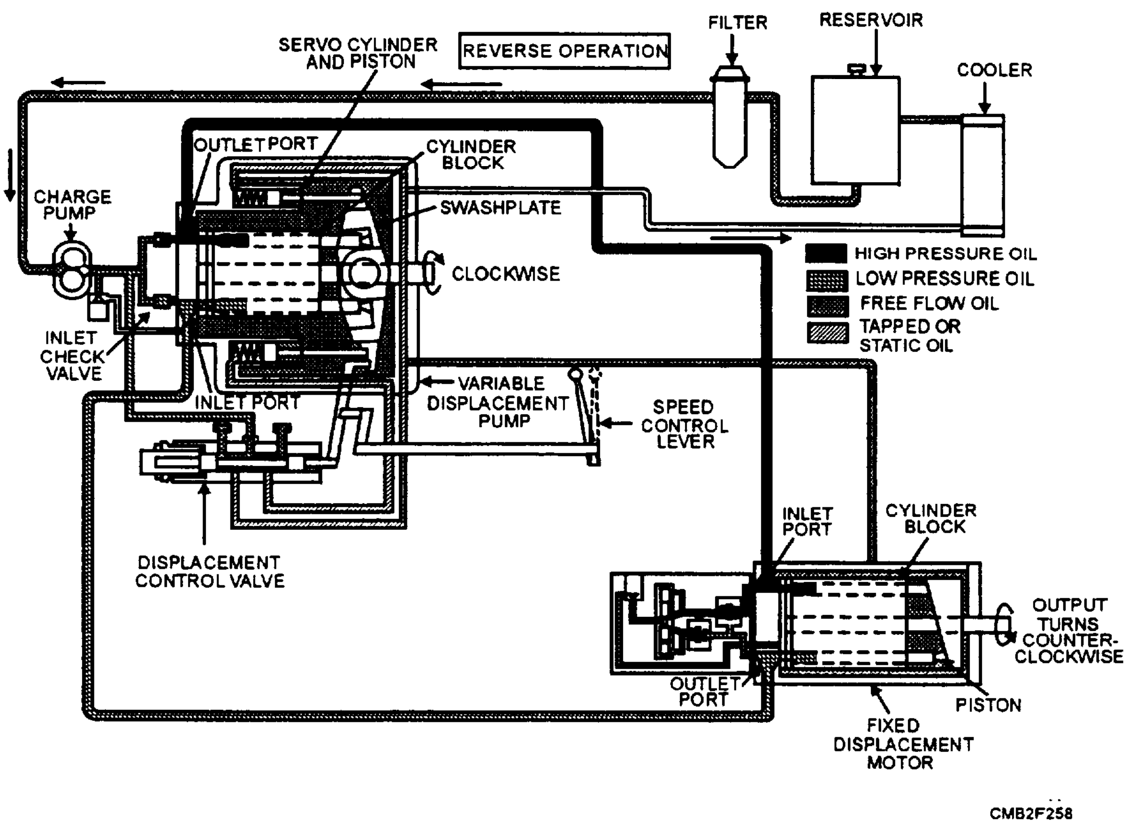

Figure 6-17.—Reverse operation.

oil to both servo cylinders and keeps the swash plate tilted. The swash plate will remain in position until the speed control lever is moved again by the operator.

With the swash plate tilted forward and the pump drive shaft and cylinder block rotating clockwise, the ports reverse and the inlet port becomes the outlet and the outlet port becomes the inlet. As the pump cylinder block rotates past the pump inlet port, a check valve opens and oil is forced by the charge pump into the piston bores that align with the inlet port of the pump. As rotation continues, the oil is pressurized and forced out of the outlet port of the pump by each of the pistons, as they align with the outlet port. This action forces oil to flow to the motor, and as high-pressure oil from the pump enters the inlet port of the motor, the pistons are pushed against the swash plate. The pistons slide down the inclined surface of the swash plate, rotating the cylinder block. This action rotates the drive shaft counterclockwise, driving the piece of equipment in reverse. As the motor cylinder block continues to rotate, oil is forced out the outlet port at low pressure and returns to the pump.

NOTE

The PUMP DRIVE SHAFT and cylinder block always rotate clockwise, but the MOTOR DRIVE SHAFT and cylinder block rotate in clockwise and counterclockwise directions, depending on the direction of the oil entering the pump.

Maintenance of Hydrostatic Drives

As with any hydraulic system, the hydrostatic drive system is fairly easy to' maintain. The fluid provides a lubricant and protects against overload. Like any other mechanism, it must be operated properly; too much speed, too much heat, too much pressure, or too much contamination will cause damage.

Before removing any part of the system, ensure that the area is clean. Use steam-cleaning equipment if available; however, do NOT let any water into the system. Ensure that all hose and line connections are tight. If steam cleaning is not possible, diesel fuel or a suitable solvent may be used. Be certain to remove all loose dirt and foreign matter that may contaminate the system. Impurities, such as dirt, lint, and chaff, cause more damage than any one thing. Always seal openings when doing work to prevent foreign matter from entering the system.

Clean the workbench or table before disassembling any hydrostatic system component for servicing. Be sure that all tools are clean and free of dirt and grease.

NOTE

NEVER perform internal service work on the shop floor or ground or where there is a danger of dust or dirt being blown into the parts.

Before disassemble of any system component for internal service, certain items must be available. These items include the following:

- Clean plastic plugs of various sizes to seal the openings when removing hydraulic hoses and lines.
- Clean plastic bags to place over the ends of the lines and hoses. Secure the bags to the line and hoses with rubber bands.
- A container of solvent to clean internal parts. Ensure that all parts are clean before replacing them. Compressed air may be used to dry the parts after cleaning.
- A container of hydraulic fluid to lubricate the internal parts as they are reassembled.
- A container of petroleum jelly to lubricate surfaces where noted by the manufacturer during reassembly.

Anytime the components are serviced and reassembled, always install new O rings, seals, and gaskets. This provides tight seals for mating parts and eliminates leakage.

NOTE

For instructions on the disassembly and reassembly of hydrostatic components, refer to the manufacturer's service manual.

Never operate the hydraulic system empty. Always check the fluid supply after servicing the system. If fluid is to be added to the system. use ONLY the fluid recommended in the service manual.

REVIEW 1 QUESTIONS

Q1. A power shift transmission has what total number offorward and reverse speeds?

Q2. What shaft in a power shift transmission has the reverse drive gear keyed to the front of the shaft?

Q3. What components are the heart of a hydrostatic drive system?

Q4. What component in a hydrostatic drive system maintains system pressure by using oil from the reservoir?

Q5. A hydrostatic drive pump with a movable swash plate is known as what type of pump?

TRACK AND TRACK FRAMES

Learning Objective: Identify the operational components of the track and track frame. Describe the maintenance procedures used on tracks and track frame assemblies.

The undercarriage of crawler-mounted equipment contains two major components—TRACK ASSEMBLY and TRACK FRAME. This undercarriage (fig. 6-18) is provided on equipment that must have positive traction to operate efficiently.

TRACK ASSEMBLY

The track assembly consists of a continuous chain surrounding the track frame and drive sprocket. The links of the chain provide a flat surface for the track rollers to pass over, as they support the equipment. Track shoes are bolted to the outside links of the chain and distribute the weight of the equipment over a large surface area.

Track Chain

Figure 6-19 shows a cutaway view of a section of track chain, showing the internal arrangement of the pins and bushings. As the tractor operates, the drive sprocket teeth contact the track pin bushings and propel the tractor along the track assembly.

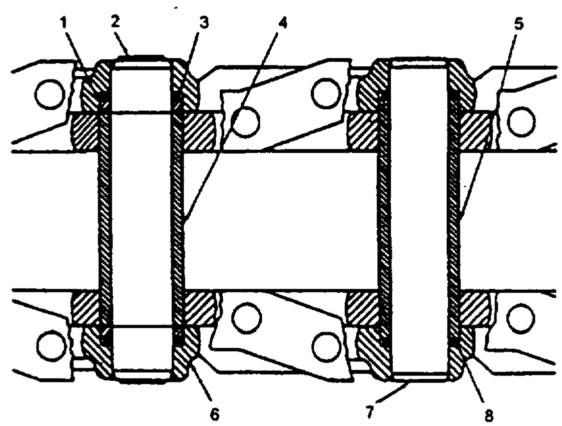

Figure 6-19.—Track chain cutaway.

The pins and bushings wear much faster than other parts of the track because of their constant pivoting, as the track rotates around the track frame. This pivoting results in internal wear of both the pin and the bushing. As the pins and bushings wear, the track lengthens. When it does, the track is adjusted to remove excessive slack.

Bushings that show lots of wear on the outside are good indicators of inner wear that is also nearing the maximum allowed by the manufacturer, if the track is to be rebuilt. To determine whether the track should be removed for rebuilding or replacement, measure the outside of the bushings and track "pitch" (length of the

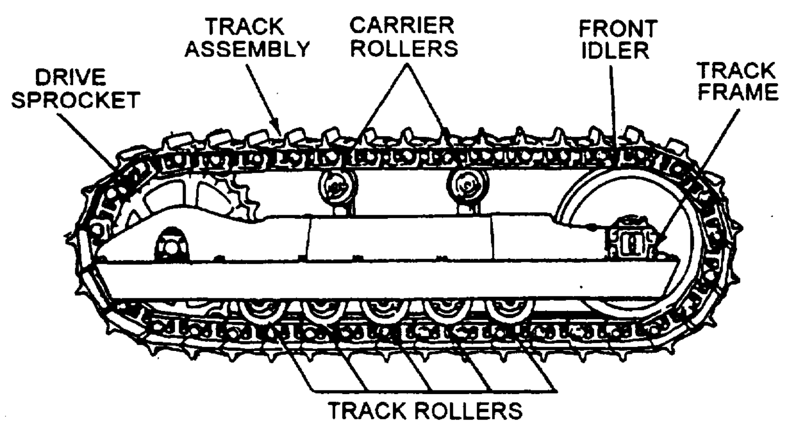

Figure 6-18.—Side view of crawler tractor chassis.

track). Use an outside caliper and ruler, as shown in figure 6-20. Measure the outside of the bushing where it shows the most wear and compare it to the manufacturer's specifications.

Measure track pitch with a ruler or tape measure after tightening the track to remove any slack, as shown in figure 6-21.

Should the bushing wear or track length be excessive, remove the track for rebuilding unless facilities and time do not permit. Rebuilding a track will nearly double the useful life of the pin and bushings.

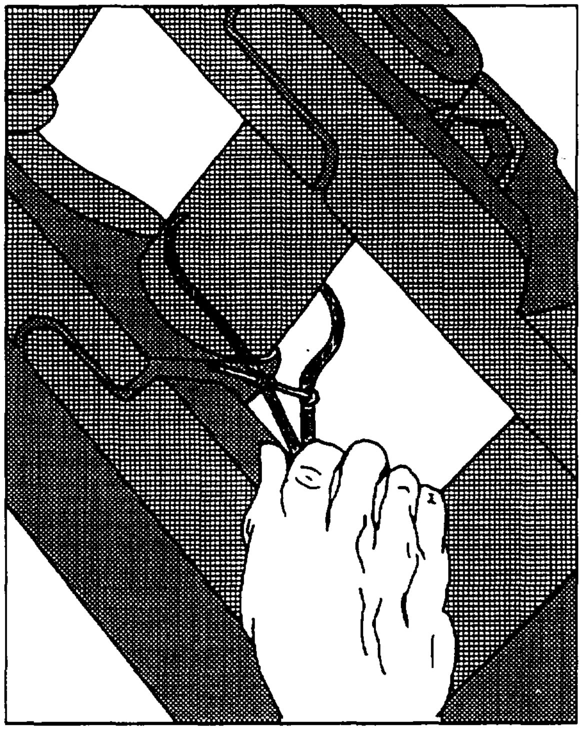

Figure 6-20.—Bushing wear measurement.

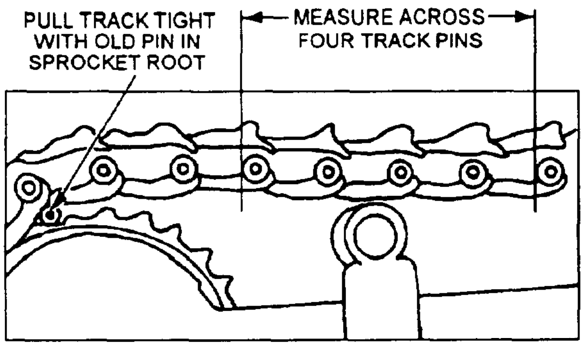

Figure 6-21.—Track pitch measurement.

Track Shoes

The most common track shoe is the grouser shoe shown in figure 6-22. This shoe is standard on all crawler-mounted dozers. The extreme service track shoe (fig. 6-23) is equipped on crawler-mounted dozers that operate primarily in rocky locations, such as rock quarries and coral beaches. Notice the grouser, or raised portion of the shoe, is heavier than the standard grouser shoe.

Another shoe common to track-mounted front-end loaders is the multipurpose shoe. This shoe has three grousers that extend a short distance above the shoe and are equally spaced across its face. The multi-purpose shoe allows more maneuverability with less wear on the track and track frame components.

NOTE

The grouser absorbs most of the wear and its condition indicates when the track needs replacement or overhaul.

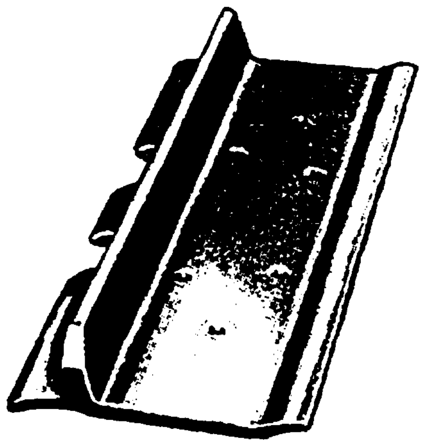

Figure 6-22.—Standard grouser shoe.

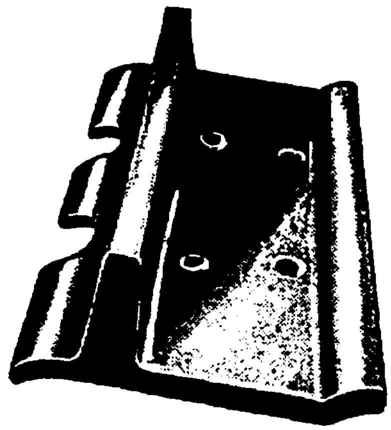

Figure 6-23.—Extreme service track shoe.

TRACK FRAME

The track frame, as the name implies, serves as a framework and support for the track assembly, rollers, front idler, recoil spring, and adjusting mechanism.

Track frame alignment may be fixed or shim adjusted depending on the manufacturer. When shims are used, there are a couple of ways alignment may be maintained. One way is using shims where the frame attaches to the rear pivot and also near the center of the track frame where it is mounted against the main frame guide brackets. Another way is to use a diagonal brace and shims at the rear pivot to align the track frame.

Track Frame Rollers

Two types of track frame rollers are used on tracked equipment—those located on the lower portion of the track frame which supports the weight of the tractor, and those above the track frame which supports the track assembly, as it passes over the track frame.

- Carrier rollers (fig. 6-24) are single-flanged rollers mounted on brackets, which extend above the track frame and supports the track assembly. Two of these rollers are on each side of the tractor. The flange extends upward between the links of the track chain. keeping the chain in alignment between the drive sprocket and the front idler.
- Track rollers (fig. 6-25) are double- and single-flanged rollers that supports the weight of the tractor, ensures that the track chain is aligned with the track frame at it passes under the rollers, and prevents side to side track movement and derailment. In a normal arrangement, a double-flanged roller is directly in front of the drive sprocket, followed by a single-flanged roller. The rollers alternate forward to the front idler.

The front idler, as shown in figure 6-25, serves as a guiding support for the track chain. The idler is spring-loaded and mounted on slides or guides that allow it to move back and forth inside the track frame, as the tractor passes over uneven terrain. The spring loading

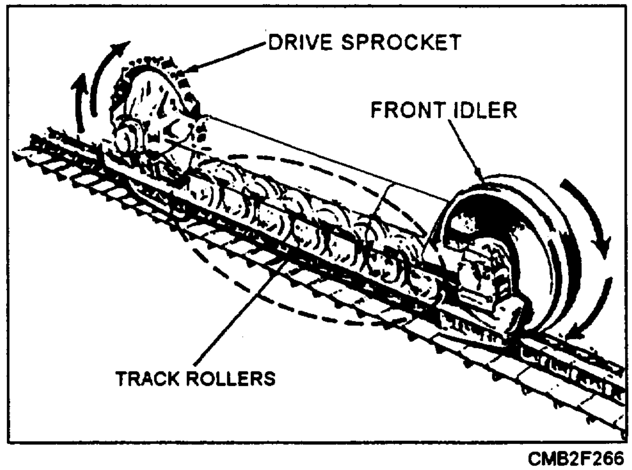

Figure 6-25.—Track rollers in position in the track frame..

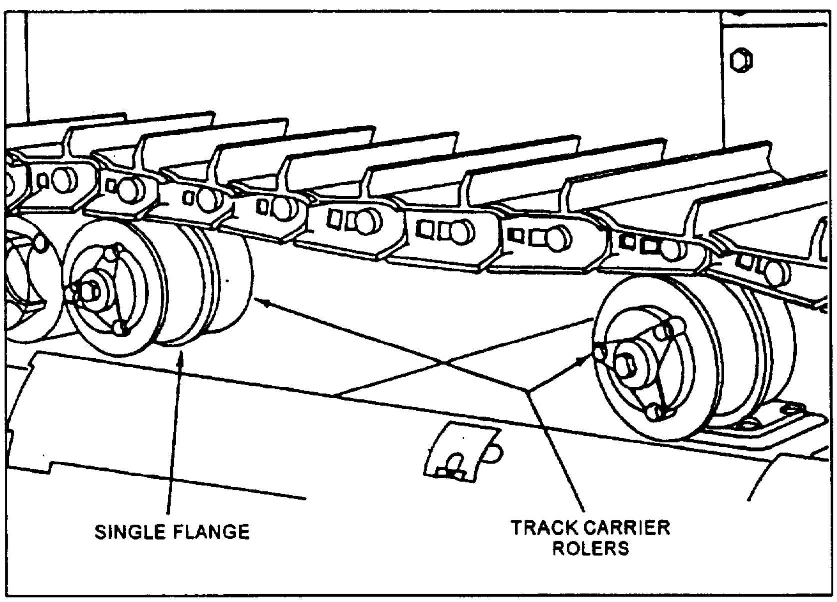

Figure 6-24.—Track carrier rollers.

effect causes the idler to maintain the desired tension regardless of operating conditions.

Recoil Spring

The recoil spring is a large coil spring placed in the track frame in a way that enables the spring to absorb shock from the front idler. The spring is compressed before installation and held in place by stops or spacers. The track adjusting mechanism, by pressing against the spring stop, maintains the desired tension on the track assembly by holding the idler and yoke in a FORWARD position. The operation of the recoil springs depends on the amount oftension on the track.

Adjusting Mechanism

The adjusting mechanism must be extended enough to remove slack between the front idler and spring. This adjustment may be made by either manual (fig. 6-26) or hydraulic (fig. 6-27) means. Many older

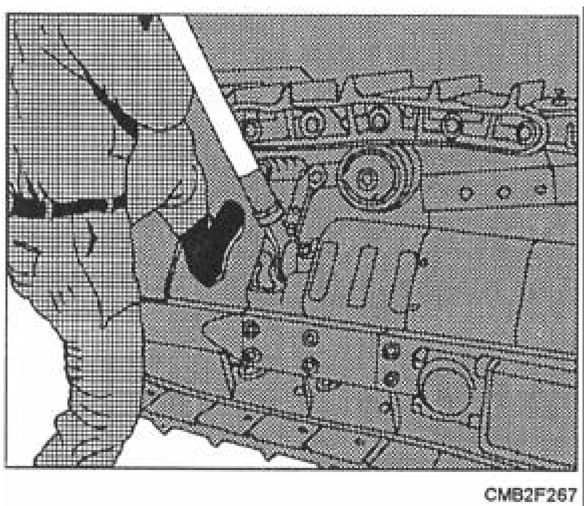

Figure 6-26.—Manual track adjustment.

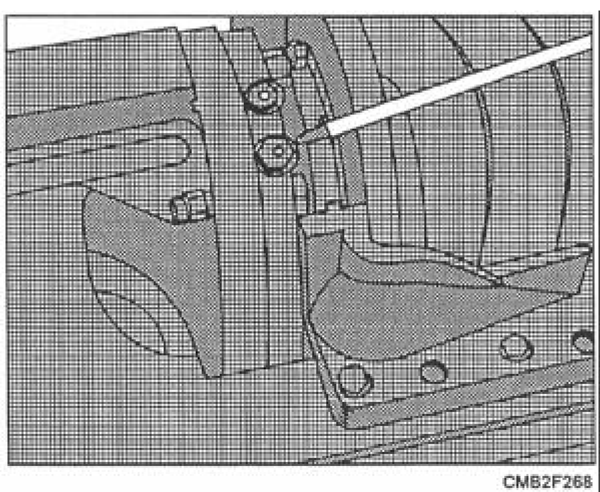

Figure 6-27.—Hydraulic track adjuster.

tractors have manual adjustments, whereas newer tractors are adjusted hydraulically with a grease gun. Grease is pumped into the yoke cylinder and extends it until enough tension is placed on the recoil spring to remove the slack from the track. Tension is released by loosening the vent screw located next to the adjustment fitting.

NOTE

DO NOT lubricate the adjustment fitting when performing maintenance on the tractor.

Track Guiding Guards

Accumulation of rock and dirt packed in the track causes the tracks to tighten, resulting in additional wear and stress on track components. The use of track guiding guards minimizes these sources of possible depreciation. Another function of the track guiding guards is maintaining proper track alignment; this is considered secondary, but actually is the most important function.

Guiding guards should be repaired when damaged, since a damaged guard is worthless as far as protection for track components or assisting in maintaining track alignment. When installing new tracks on a piece of equipment, check the condition of the guards. These guards should be in a condition to guide the track squarely into alignment with the rollers properly. The three guards are as follows:

- The FRONT GUIDING GUARDS receive the track from the idler and hold it in line for the first roller. The front roller then can fully be utilized for its intended purpose—carrying its share of the load without having to climb the side of an improperly aligned track.
- The REAR GUIDING GUARDS hold the track in correct alignment with the driving sprocket, permitting a smooth even power flow from the sprocket to the track. With proper alignment, gouging of the track link and sprocket teeth is eliminated.
- The CENTER GUIDING GUARDS or track roller guards are available as attachments. These center guards keep the track in line between the rollers when operating in rocky, steep, or uneven terrain. The center guards reduce the wear on roller flanges and track links.

MAINTENANCE OF TRACK AND TRACK FRAME ASSEMBLIES

Some maintenance of track and track frames are performed at the jobsite by the field maintenance crew. This maintenance consists of track adjustment, lubrication based on hours as required by the manufacturer, and inspection of the track and track frame components.

Track Adjustment

If the tracks are adjusted too tightly, there will be too much friction between the pins and bushings when the track links swivel. as they travel around the sprocket and front idler. This friction causes the pins, bushings, links, sprocket, and idler to wear rapidly. Friction in a tight track also robs the tractor of needed horsepower.

Tracks that are too loose fail to stay aligned and tend to come off when the tractor is turned. As a result, the idler flanges, roller flanges, and the sides of the sprocket teeth wear down. A loose track will whip at high tractor ground speed, damaging the carrier rollers and their supports. If loose enough, the drive sprockets will jump teeth (slide over track bushings) when the tractor moves in reverse. Should this happen, the sprocket and bushings will wear rapidly.

One method for determining proper track tension is placing a straightedge over the front carrier roller and idler with all the slack removed from the rest of the track. Using a ruler. measure from the top of the track shoe to the bottom edge of the straightedge (fig. 6-28). For the correct measurement, refer to the manufacturer's manual.

If it becomes necessary to adjust the track in the field, the following method can be used. Remove all

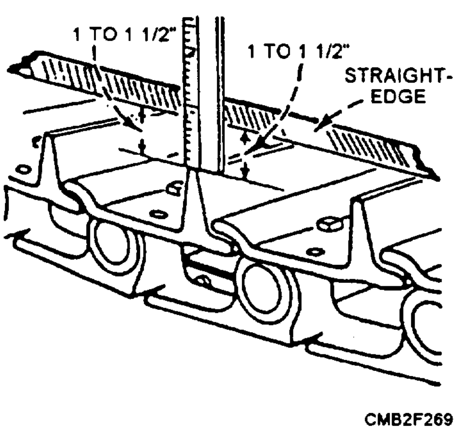

Figure 6-28.—Checking track adjustment.

slack from the track. With all slack removed, release the pressure until the front idler moves back 1/2 inch. This will provide the required slack in the track until the tractor can be readjusted to the manufacturer's specifications.

NOTE

Always check the manufacturer's maintenance manual for the proper procedures when adjusting tracks.

Lubrication

The track pins and bushing are hardened and require no lubrication. Many rollers and idlers are equipped with lifetime seals that are factory lubricated and sealed. However, track rollers, carrier rollers, and idlers equipped with grease fittings must be lubricated on a scheduled basis that is set by the manufacturer.

NOTE

ONLY use a hand-operated grease gun on these fittings and pump only until resistance is felt. Further pumping will damage the seals.

Inspection

When performing routine maintenance, inspect the complete track and undercarriage for signs of abnormal wear, leaking rollers or idlers, and misaligned, loose, or missing parts. Should you find any loose track shoes, you should check the torque on all the shoe bolts. Any bolts not meeting specifications should be retightened to the prescribed torque.

If the track appears to be out of alignment, report this to your supervisor who shall determine what action is required. Leaking roller and idler seals should be replaced as soon as possible to prevent any further damage to the equipment.

Shop Repairs

Repairs made to tracks and track frames in the maintenance shop are usually limited to replacing roller or idler seals and bearings or repairing a hydraulic track adjuster. On occasion, you may find a roller or track that is badly worn and requires replacement.

NOTE

NEVER replace components of the track or track frame without consulting the wear limitation charts in the manufacturer's service manual.

TRACK REMOVAL (fig. 6-29).—Steps for the removal of the track are as follows:

1. RELEASE TRACK TENSION. Either by manually backing off the track adjuster or loosening the vent screw on the hydraulic track adjuster.

2. REMOVE THE MASTER PIN. The master pin can be identified by a locking device or hole drilled in its end that distinguishes it from the other pins in the chain. Move the tractor backward slowly or, on some models, forward to bring the master pin just below the level of the drawbar. Place a block under the grouser on a shoe that allows the master pin to be centered on the front idler. With the master pin centered on the front idler, remove any locking device. If the master pin had a locking device, the pin can be removed by using a sledgehammer and a soft metal driftpin. Should the pin be drilled, a portable press must be used to remove the pin. Do not lose the bushings, which may drop out with the pin.

3. REMOVE THE TRACK FROM THE CARRIER ROLLERS AND IDLER. Slowly move the tractor forward or backward away from the loose ends of the track. Make sure no one is in the way of the tractor or the loose end of the track when it falls off the sprocket or front idler.

4. MOVE THE TRACTOR OFF THE TRACK. Place a plank at the rear of the track. The plank should be about the same thickness as the track, yet narrow enough to fit between the track frame and guards, and long enough so that the entire tractor can rest on the plank.

NOTE

After removing the tracks, always see that the tractor is securely blocked while repairs are being performed.

Anytime a track is removed, thoroughly inspect the track frame components for excessive wear and misalignment. Removal, disassembly, and replacement vary by model and manufacturer. Consult the manufacturer's service manual for exact procedures.

REPLACING TRACKS.—To replace the tracks, back the tractor off the plank and onto the new tracks so the drive sprocket properly meshes with the track rail. Continue backing until the tractor is just ahead of the rear end of the track. Then place a bar in the track (fig. 6-30), and help the track climb over the sprocket, carrier rollers, and idler as the tractor is driven forward. When the track comes together, install the master pin and any locking device. Once the track is together, adjust the track tension using the manufacturer's recommended procedures.

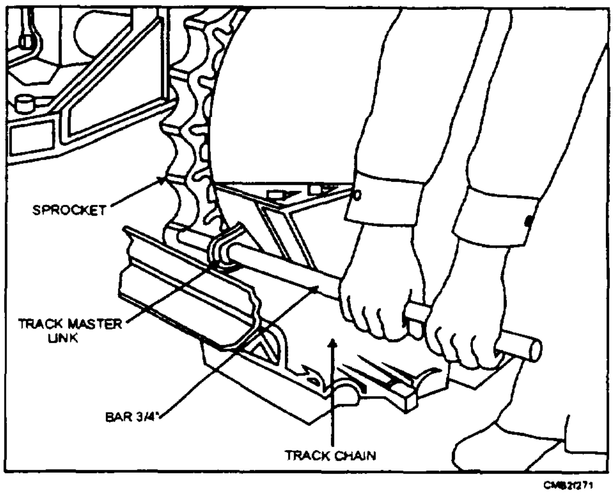

Figure 6-30.—Pulling track over sprocket.

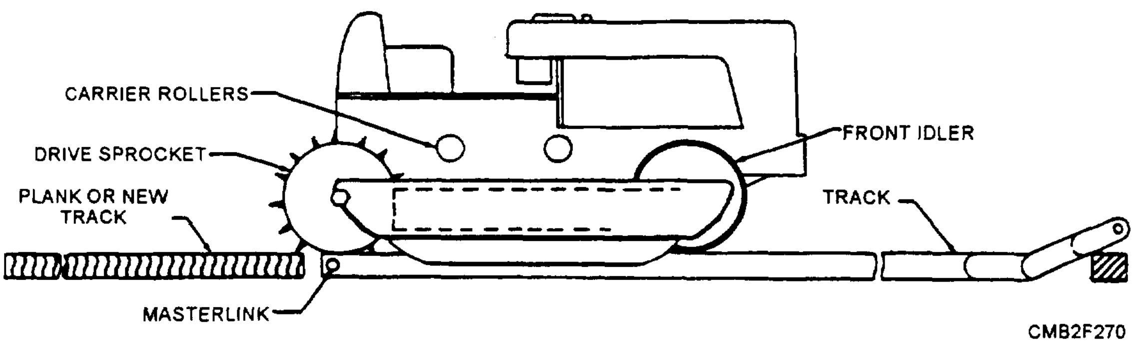

Figure 6-29.—Removing tracks.

REVIEW 2 QUESTIONS

Q1. What components of a track chain wear faster than the other components?

Q2. What measuring device is used to measure track pitch?

Q3. What is the most common type of track shoe?

Q4. What component of the track frame serves as a guiding support for the track chain?

Q5. What component of the track frame holds the track in correct alignment with the driving sprocket?

WINCHES AND WIRE ROPE

Learning Objective: Describe the operation of a winch. Identify the characteristics and maintenance of wire rope.

Using a winch and some type of rigging, a vehicle can pull itself or another vehicle through such obstacles as muddy or rough terrain. This is the primary reason for providing winches on military vehicles.

In the Naval Construction Force (NCF), an in-depth management program for maintenance and use of all rigging gear is required to ensure all operations are performed safely and professionally. These guidelines are outlined in the COMSECOND/COMTHIRDNCBINST 11200.11, *Use of Wire Rope Slings and Rigging Hardware in the Naval Construction Force* and the NAVFAC P-307, *Management of Weight Handling Equipment.*

WINCHES

Most winches that you will encounter are used on tactical vehicles and construction equipment. On tactical equipment, the winch is mounted behind the front bumper and is secured to the front cross member of the frame or between the two side frame rails. In some cases, it may be mounted behind the cab of the vehicle. The typical front-mounted winch is a jaw-clutch worm-gear type (fig. 6-31).

The jaw-clutch winch consists of a worm gear that is keyed to a shaft. A bushed drum is mounted on the worm-gear shaft, which is controlled by a hand-operated sliding clutch. The worm shaft is driven by power from the power takeoff through a solid drive shaft and universal joints. The universal joint yoke, connected to the worm shaft of the winch, has a provision for a shear pin that is made of mild steel. This pin has a predetermined breaking strength that allows it to shear when the winch is overloaded.

A hand-operated sliding clutch is keyed to the worm-gear shaft outside of the winch drum and must be engaged with the jaws on the side of the winch drum when the winch is to be operated. Disengagement of the sliding clutch permits the drum to turn on the worm-gear shaft.

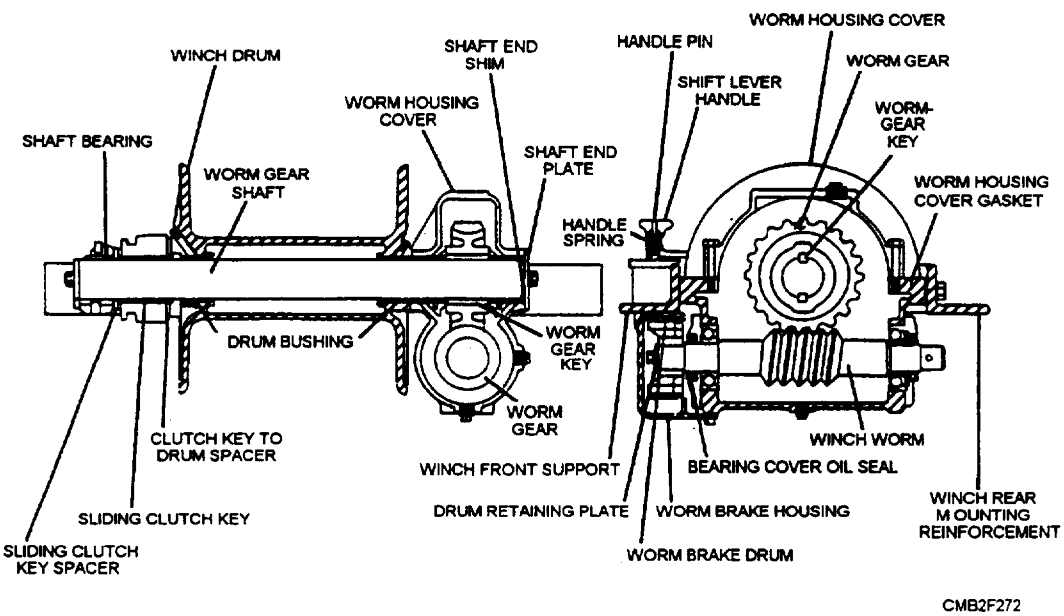

Figure 6-31.—Jaw-clutch worm-gear winch.

The two brakes that provide control of the winch drum are as follows:

- The WORM BRAKE SHAFT prevents the winch drum from rotating under load when the power takeoff is disengaged.
- The SHIFTER BRACKET BRAKE prevents the drum from overrunning the cable when the cable is being unreeled.

Some winches may be equipped with an automatic level-winding device to spool the cable on the drum in tight, even coils, and layers. This prevents crushing of the cable due to loose, crossed coils and layers, and it allows off leads of the cable while maintaining level winding.

A broken shear pin usually causes faulty operation of winches. Internal damage of the winch can be caused by the use of a shear pin that has too high a breaking strength. Internal winch failure, resulting from overload, is commonly found to be sheared keys or a broken worm shaft. Often, when the cable is wound unevenly under tension, the winch housing will be cracked or broken. This will require replacement of the assembly.

NOTE

NEVER install a shear pin that in not of the proper shearing strength. Damage to the winch will occur when overloaded.

The winch that you will most likely encounter on construction equipment is the one attached to the rear of a crawler tractor, also known as a dozer. It is mounted on the rear of the dozer (fig. 6-32) and is directly geared to the rear power takeoff. This arrangement permits development of a line of pull that is 50 to 100 percent greater than straight dozer pull. The winch is used for uprooting trees and stumps, hoisting and skidding stress, freeing mired equipment, and support amphibious construction operations.

When performing maintenance on a winch, ensure that the gear case has the recommended amount and type of lubricant. Should disassemble of the winch be required for repairs, follow the procedures given in the manufacturer's manual.

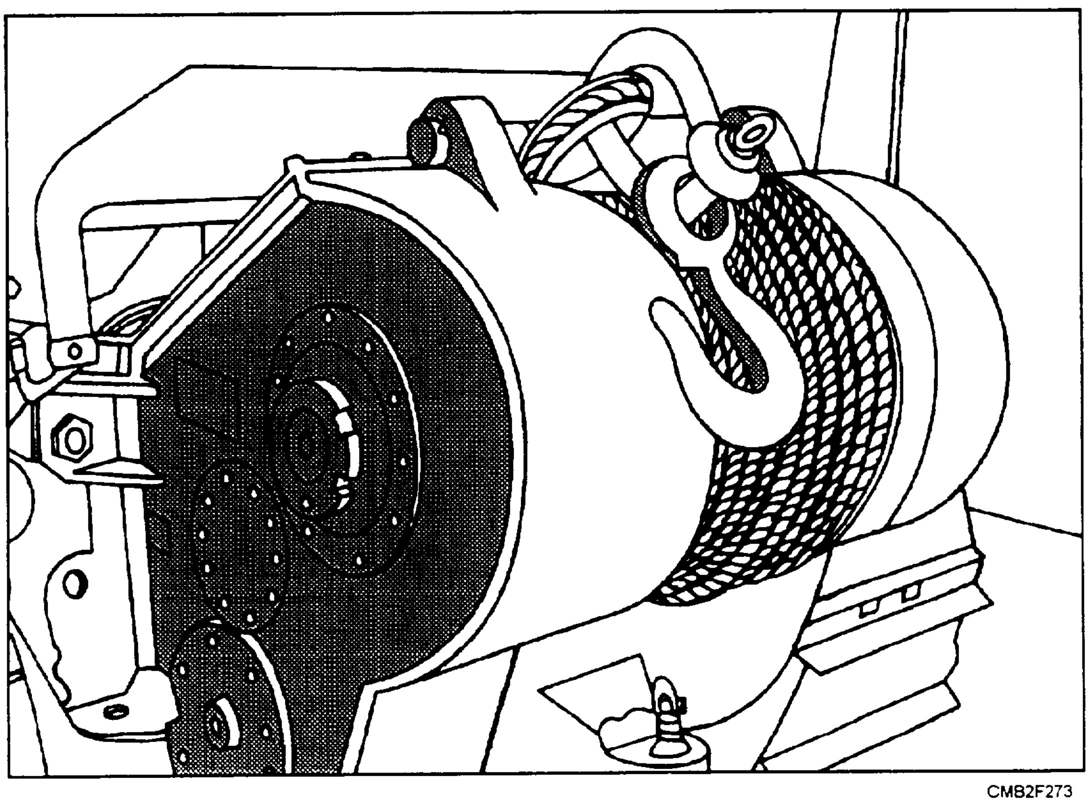

Figure 6-32.—Winch attachment on a dozer.

WIRE ROPE

Many of the movable components on cranes and attachments are moved by wire rope. Wire rope is a complex machine, composed of a number of precise moving parts. The moving parts of wire rope are designed and manufactured to bear a definite relationship to one another to have the necessary flexibility during operation.

Wire rope may be manufactured by either of two methods. If the strands, or wires, are shaped to conform to the curvature of the finished rope before laying up, *the* rope is termed *PREFORMED WIRE ROPE.* If they are not shaped before fabrication, the wire rope is termed *NON-PREFORMED WIRE ROPE.* The most common type of manufactured wire rope is preformed. When cut, the wire rope tends not to unlay and is more flexible than non-preformed wire rope. With non-preformed wire rope, twisting produces a stress in the wires; therefore, when it is cut or broken, the stress causes the strands to unlay.

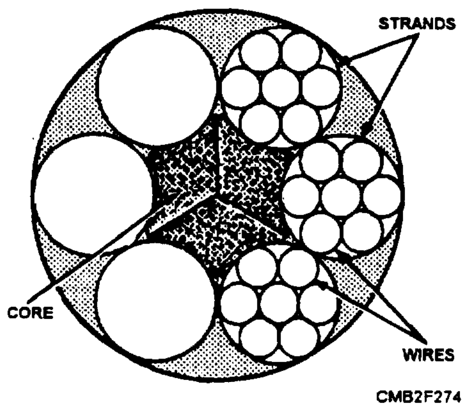

Figure 6-33.—Composition of wire rope.

CAUTION

When the wire is cut or broken, the almost instantaneous unlaying of the wire or strands of the non-preformed wire rope can cause serious injury. This situation is apt to occur especially to someone who is careless or not familiar with this characteristic of the rope.

Composition of Wire Rope

Wire rope is composed of three parts—wires, strands, and core (fig. 6-33). A predetermined number of wires of the same or different size are fabricated in a uniform arrangement of definite lay to form a strand. The required number of strands are then laid together symmetrically around the core to form the wire rope.

WIRE.—The basic component of the wire rope is the wire. The wire may be made of steel, iron, or other metal in various sizes. The number of wires to a strand varies, depending on the purpose for which the wire rope is intended. The number of strands per rope and the number of wire per strand designate wire rope. Thus a 1/2-inch 6 x 19 rope has six strands with nineteen wires per strand. It has the same outside diameter as a 1/2-inch 6 x 37 rope that has six strands with thirty-seven wires (of a smaller size) per strand.

STRAND.—The design arrangement of a strand is called the construction. The wires in the strand may be all the same size or a mixture of sizes. The most common strand constructions are Ordinary, Seale, Warrington, and Filler (fig. 6-34) as follows:

- ORDINARY construction wires are all the same size.

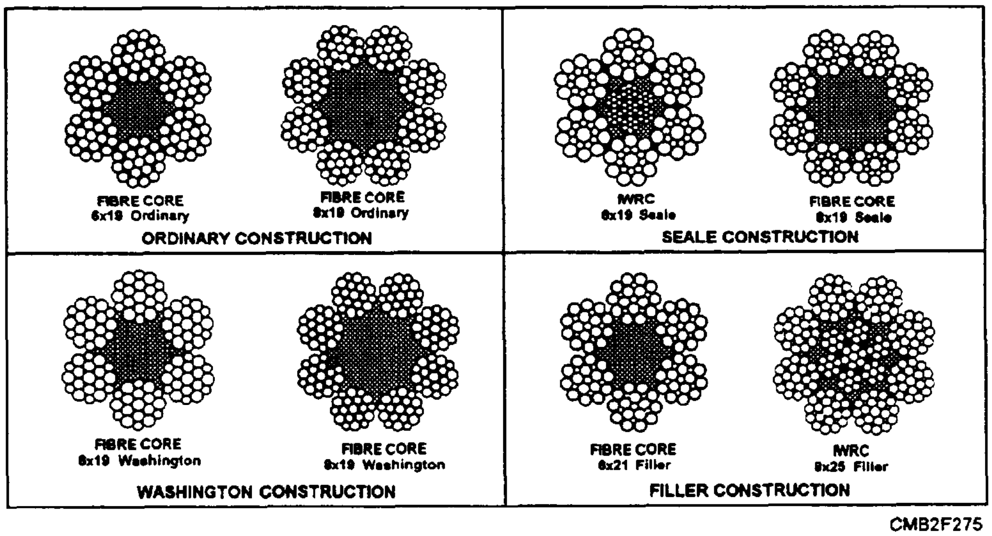

Figure 6-34.—Common strand construction.

- SEALE is where larger diameter wires are used on the outside of the strand to resist abrasion and smaller wires inside to provide flexibility.
- WARRINGTON is where alternate wires are large and small to combine great flexibility with resistance to abrasion.
- FILLER is where very small wires fill in the valleys between the outer and inner rows of wires to provide good abrasion and fatigue resistance.

CORE.—The wire rope core supports the strands laid around it. The three types of wire rope cores are fiber, wire strand, and independent wire rope (fig. 6-35).

- A fiber core may be a hard fiber, such as manila hemp, plastic, paper, or sisal. The fiber core offers the advantage of increased flexibility. It also serves as a cushion to reduce the effects of sudden strain and acts as an oil reservoir to lubricate the wire and strands (to reduce friction). Wire rope with a fiber core is used when flexibility of the rope is important.
- A wire strand core resists more heat than a fiber core and also adds about 15 percent to the strength of the rope; however, the wire strand core make the wire less flexible than a fiber core.
- An independent wire rope core is a separate wire rope over which the main strands of the rope are laid. This core strengthens the rope, provides support against crushing, and supplies maximum resistance to heat.

Grades of Wire Rope

The three primary grades of wire rope are as follows:

- Mild plow steel wire rope is tough and pliable. It can stand repeated strain and stress and has a tensile strength (resistance to lengthwise stress) from 200,000 to 220,000 pounds per square inch (psi). These characteristics make it desirable for cable tool drilling and other purposes where abrasion is encountered.
- Plow steel wire rope is usually tough and strong. This steel has a tensile strength of 220,000 to 240,000 psi. Plow steel wire rope is suitable for hauling, hoisting, and logging.
- Improved plow steel wire rope is one of the best grades of rope available and is the most common rope used in the NCF. This type of rope is stronger, tougher, and more resistant to wear than the others. Each square inch of improved plow steel can stand a strain of 240,000 to 260,000 psi. This makes it especially useful for heavy-duty service, such as on cranes with excavating and weight-handling equipment.

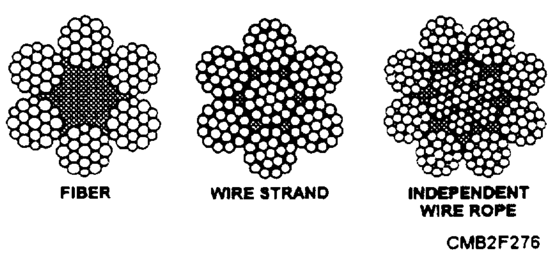

Figure 6-35.—Core construction.

Lays of Wire Rope

The term *lay* refers to the direction of the twist of the wires in a strand and to the direction that the strands are laid in the rope. In some instances, both the wires in the strand and the strands in the rope are laid in the same direction; and, in other instances, the wires are laid in one direction and the strands are laid in the opposite direction, depending on the intended use of the rope. Most manufacturers specify the types and lays of wire rope to be used on their piece of equipment. Be sure and consult the operator's manual for proper application.

The five different lays used in wire rope are as follows (fig. 6-36):

- RIGHT REGULAR LAY has the wires in the strands laid to the left, while the strands are laid to the right to form the wire rope.
- LEFT REGULAR LAY has the wires in the strands laid to the right, while the strands are laid to the left to form the wire rope. In this lay, each step of fabrication is exactly opposite from the right regular lay.
- RIGHT LANG LAY has the wires in the strands and the strands in the rope laid to the right.
- LEFT LANG LAY has the wire in the strands and the strands in the rope laid to the left.
- REVERSE LAY has the wires in one strand laid to the right, the wire in the nearby strand are laid to the left, the wire in the next strand are to the right, and so forth, alternating direction from one strand to the other. Then all strands are laid to the right.

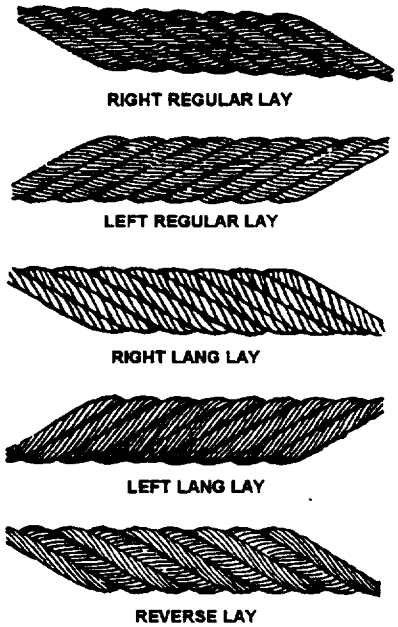

Figure 6-36.—Lays of wire rope.

Characteristics of Wire Rope

The main types of wire rope used consist of 6, 7, 12, 19, 24, or 37 wires per strand. Usually, the wire rope has six strands laid around the core.

The two most common types of wire rope, 6 x 19 and 6 x 37, are shown in figure 6-37. The 6 x 19 type (having six strands with 19 wires in each strand) are the stiffest and strongest construction of the types of wire rope suitable for general hoisting operations. The 6 x 37 wire rope (six strands with 37 wires in each strand) are very flexible, making it suitable for cranes and similar equipment.

Several factors must be considered whenever a wire rope is selected for use in a particular kind of operation. The manufacture of wire rope which can withstand equally well all kinds of wear and stress, it

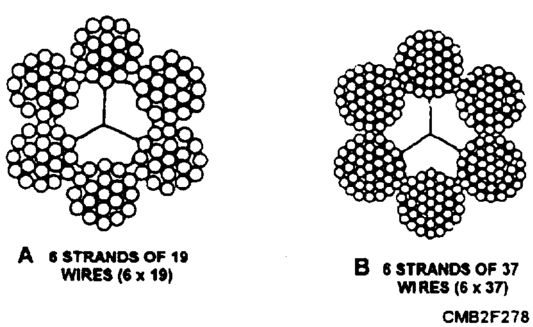

Figure 6-37.—A. 6 x 19 wire rope; B. 6 x 37 wire rope.

may be subjected to, is not possible. Because of this, selecting a rope is often a matter of compromise—sacrificing one quality to have some other more urgently needed characteristic.

TENSILE STRENGTH.—Tensile strength is the strength necessary to withstand a certain maximum load applied to the rope. It includes a reserve of strength measured in a so-called factor of safety.

CRUSHING STRENGTH.—Crushing strength is the strength necessary to resist the compressive and squeezing forces that distort the cross section of a wire rope, as it runs over sheaves, rollers, and hoist drums when under a heavy load. Regular lay rope distorts less in these situations than lang lay.

FATIGUE RESISTANCE.—Fatigue resistance is the ability to withstand the constant bending and flexing of wire rope that runs continuously on sheaves and hoist drums. Fatigue resistance is important when wire rope must run at high speeds. Such constant and rapid bending of the rope can break individual wires in the strands. Lang lay ropes are best for service requiring high fatigue resistance. Ropes with similar wires around the outside of their strands also have a greater resistance, since these strands are more flexible.

ABRASION RESISTANCE.—Abrasion resistance is the ability to withstand the gradual wearing away of the outer metal, as the rope runs across sheaves and hoist drums. The rate of abrasion depends mainly on the load carried by the rope and its running speed. Generally, abrasion resistance in a rope depends on the type of metal of which the rope is made and the size of the individual outer wires. Wire rope made of harder steels, such as improved plow steel, has a considerable resistance to abrasion. Ropes that have larger wires forming the outside of their strands are more resistant to wear than rope having smaller wires which wear away more quickly.

CORROSION RESISTANCE.—Corrosion resistance is the ability to withstand the dissolution of the wire metal that results from chemical attack by moisture in the atmosphere or elsewhere in the working environment. Ropes that are put to static work, such as guy wires, may be protected from corrosive elements by paints or other special dressings. Wire rope may be galvanized for corrosion protection. Most wire rope used in crane operations must rely on their lubricating dressing to double as a corrosion preventive.

Measuring Wire Rope

Wire rope is designated by its diameter in inches, as shown in figure 6-38. The correct methods of measuring wire rope is to measure from the top of one strand to the top of the strand directly opposite it. The wrong way is to measure across two strands side by side.

To ensure an accurate measurement of the diameter of a wire rope, always measure the rope at three places at least 5 feet apart. Use the average of the three measurements as the diameter of the rope.

Wire Rope Safe Working Load

The term safe working load (SWL) of wire rope means the load that can be applied and still obtain the most efficient service and also prolong the life of the rope. For the safe working load of wire rope, refer to the manufacturer's certification of published breaking strength or the actual breaking strength of a piece of wire rope taken from the reel and tested.

Wire Rope Failure

Some of the common causes of wire rope failure are the following:

- Using incorrect size, construction, or grade
- Dragging over obstacles
- Lubricating improperly
- Operating over sheaves and drums of inadequate size
- Overriding or cross winding on drums
- Operating over sheaves and drums with improperly fitted grooves or broken flanges
- Jumping of sheaves
- Exposing to acid or corrosive liquid or gases
- Using an improperly attached fitting
- Allowing grit to penetrate between the strands promoting internal wear
- Subjecting to severe or continuing overload
- Using an excessive fleet angle

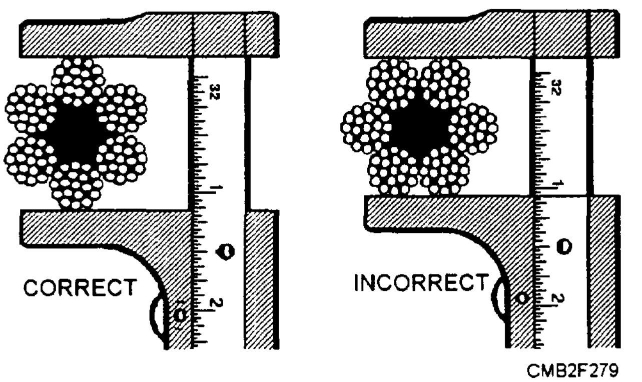

Figure 6-38.—Correct and incorrect methods of measuring wire rope.

Handling and Care of Wire Rope

To render safe, dependable service over a maximum period of time, you should take good care and upkeep that is necessary to keep wire rope in good condition. Various ways of caring for and handling wire rope are described below.

COILING AND UNCOILING.—Once a new reel has been opened, it may be coiled or faked down, like line. The proper direction of coiling is counterclockwise for left lay and clockwise for right lay wire rope. Because of the general toughness and resilience of wire, it tends now and then to resist being coiled down. When this occurs, it is useless to fight the wire by forcing down the turn because it will only spring up again. But if it is thrown in a back turn, as shown in figure 6-39, it will lie down properly. A wire rope, when faked down, will run right off, like line; but when wound in a coil, it must always be unwound.

Wire rope tends to kink during uncoiling or unreeling, especially if it has been in service long. A kink can cause a weak spot in the rope that wears out quicker than the rest of the rope.

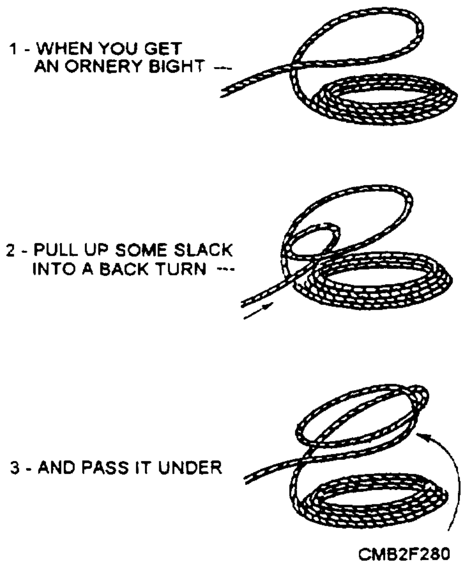

Figure 6-39.—Throwing a back turn.

A good method for unreeling wire rope is to run a pipe or rod through the center and mount the reel on drum jacks or other supports so the reel is off the ground, as shown in figure 6-40. In this way, the reel will turn as the rope is unwound, and the rotation of the reel helps keep the rope straight. During unreeling, pull the rope straightforward, and avoid hurrying the operation. As a safeguard against kinking, NEVER unreel wire rope from a reel that is stationary.

To uncoil a small coil of wire rope, simply stand the coil on edge and roll it along the ground like a wheel, or hoop, as also shown in figure 6-40. NEVER lay the coil flat on the floor or ground and uncoil it by pulling on the end, because such practice can kink or twist the rope.

KINKS.—One of the most common forms of damage resulting from improper handled wire rope is the development of a kink. A kink starts with the formation of a loop, as shown in figures 6-41 and 6-42.

A loop that has not been pulled tight enough to set the wires or strands or the rope into a kink can be removed by turning the rope at either end in the proper direction to restore the lay (fig. 6-43). If this is not done and the loop is pulled tight enough to cause a kink (fig. 6-44), the kink will result in irreparable damage to the rope (fig. 6-45).

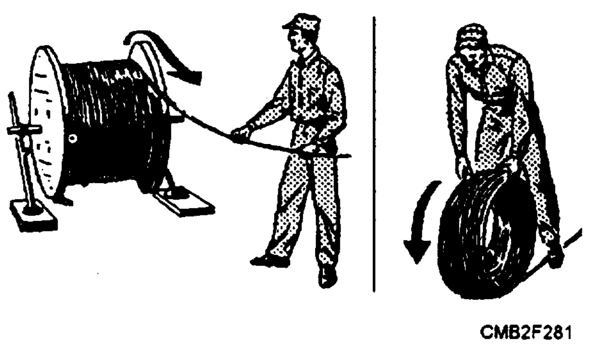

Figure 6-40.—Unreeling wire rope (left); uncoiling wire rope (right).

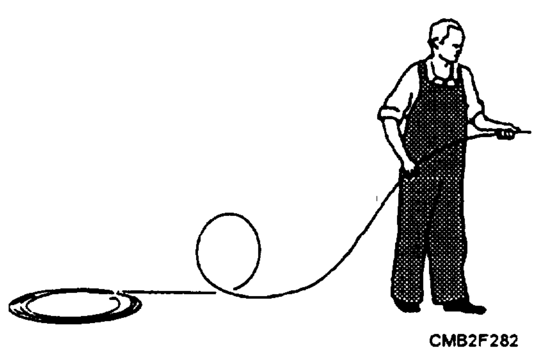

Figure 6-41.—Improper handling.

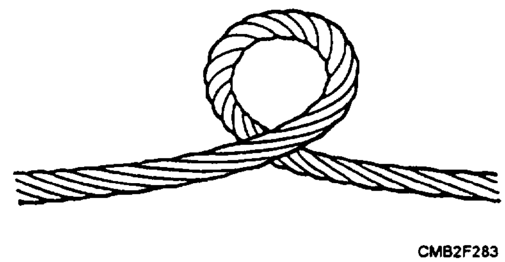

Figure 6-42.—Wire rope loop.

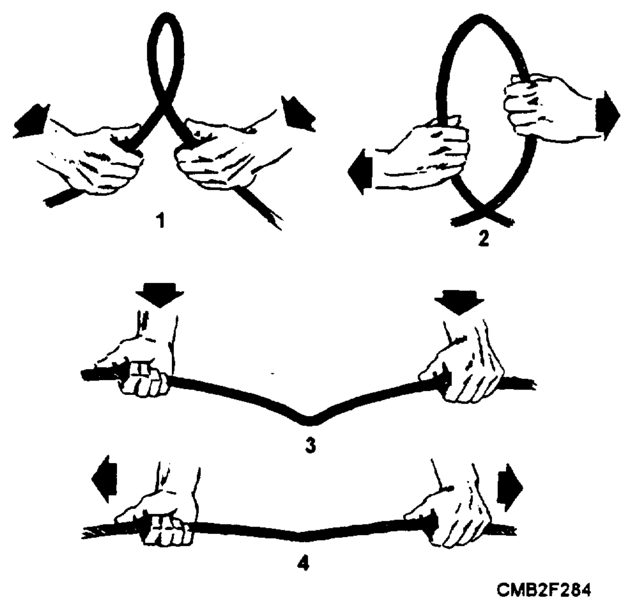

Figure 6-43.—The correct way to take out a loop in a wire rope.

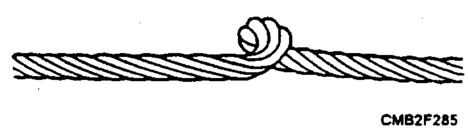

Figure 6-44.—Wire rope kink.

Figure 6-45.—Kink damage.

Kinking can be prevented by proper uncoiling and unreeling methods and by the correct handling of the rope throughout its installation.

DRUM WINDING.—Spooling wire rope on a crane hoist drum causes a slight rotating tendency of the rope due to the spiral lay of the strands. Two types of hoist drums used for spooling wire rope are as follows:

1. Grooved drum. When grooved drums are used, the grooves generally give sufficient control to wind the wire rope properly, whether it is right or left lay rope.

2. Smooth-faced drum. Smooth-faced drums are used where the only other influence on the wire rope is winding on the first layer is the fleet angle. The slight rotational tendency of the rope can be used as an advantage in keeping the winding tight and uniform.

NOTE

Using the wrong type of wire rope lay causes the rotational tendency of the rope to be a disadvantage, because it results in loose and nonuniform winding of the rope on the hoist drum.

Figure 6-46 shows drum-winding diagrams for selection of the proper lay of rope. Standing behind the hoist drum and looking towards an oncoming overwind rope, the rotating tendency of right lay rope is toward the left; whereas the rotating tendency of a left lay rope is to the right.

Refer to figure 6-46. With overwind reeving and a right lay rope on a smooth-faced drum, the wire rope bitter end attachment to the drum flange should be at the left flange. With underwind reeving and a right lay rope, the wire rope bitter end should be at the right flange.

When wire rope is run off one reel onto another or onto a winch or drum, it should be run from TOP TO TOP or from BOTTOM TO BOTTOM, as shown in figure 6-47.

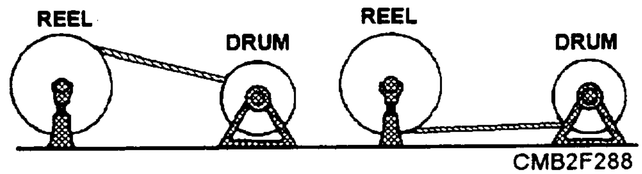

Figure 6-47.—Transferring wire rope from reel to drum.

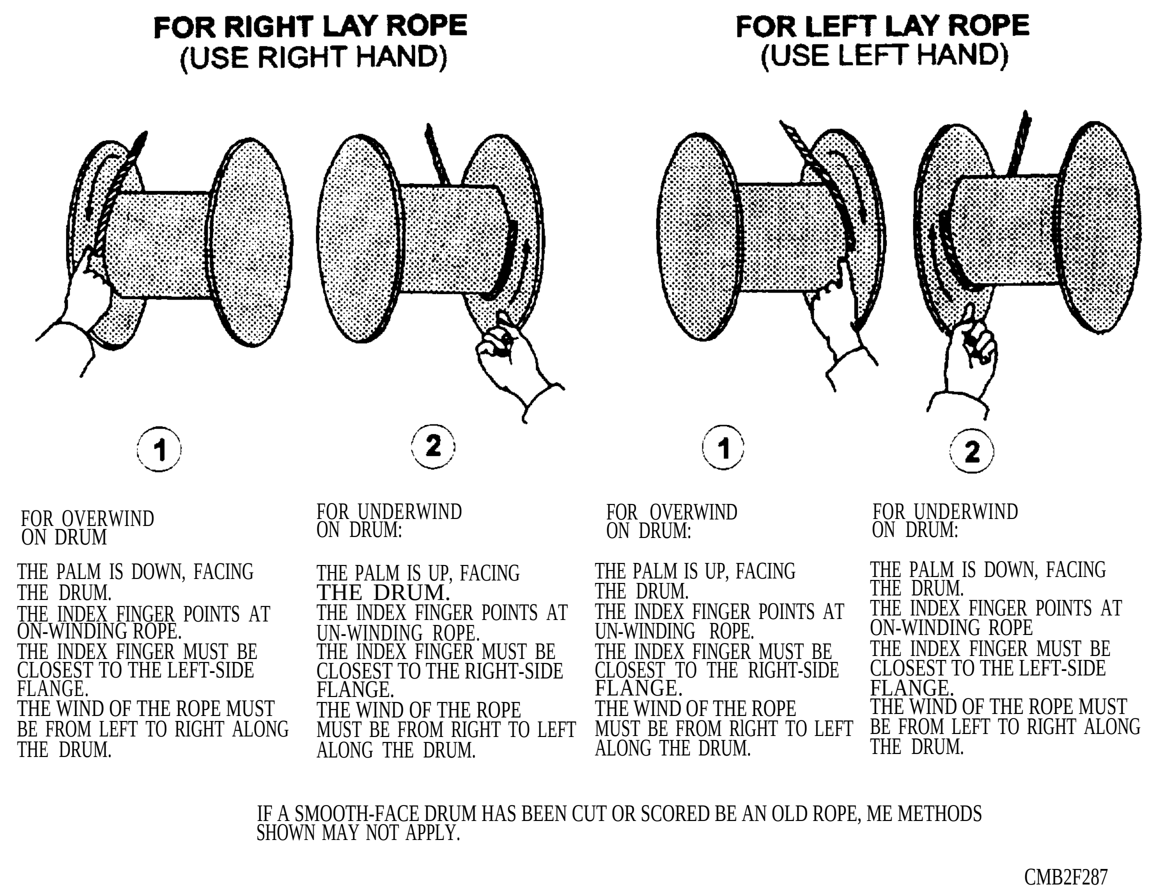

Figure 6-46.—Different lays of wire rope winding on hoisting drums.

FLEET ANGLE.—The fleet angle is formed by running wire rope between a sheave and a hoist drum whose axles are parallel to each other (fig. 6-48). Too large a fleet angle can cause the wire rope to climb the flange of the sheave and can also cause the wire rope to climb over itself on the hoist drum.

SIZES OF SHEAVES.—The diameter of a sheave should never be less than 20 times the diameter of the wire rope. An exception is 6 x 37 wire for which a smaller sheave can be used, because it is more flexible.

REVERSE BENDS.—Whenever possible, drums, sheaves, and blocks used with wire rope should be placed to avoid reverse or S-shaped bends. Reverse bends cause the individual wires or strands to shift too much and increase wear and fatigue. For ‘a reverse bend, the drums and blocks affecting the reversal should be of a larger diameter than ordinarily used and should be spaced as far apart as possible.

SEIZING AND CUTTING.—The makes of wire rope are careful to lay each wire in the strand and each strand in the rope under uniform tension. If the ends of the rope are not secured properly, the original balance of tension will be disturbed. Maximum service is not obtainable because some strands can carry a greater portion of the load than others can. Before cutting steel wire rope, place seizing on each side of the point where the rope is to be cut.

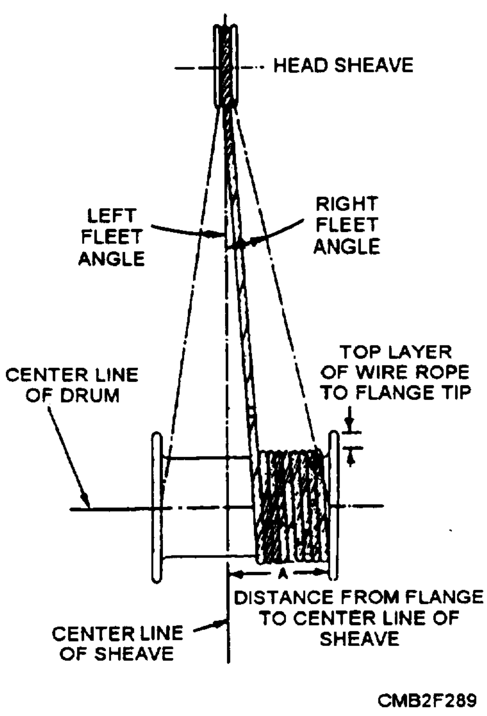

Figure 6-48.—Fleet angle relationship.

A rule of thumb for determining the size, number, and distance between seizing is as follows:

- The number of seizing to be applied equals approximately three times the diameter of the rope.

Example: 3 x 3/4-inch-diameter rope = 2 1/4 inches. Round up to the next higher whole number and use three seizing.

- The width of each seizing should be 1 to 1 1/2 times as long as the diameter of the rope.

Example: 1 x 3/4-inch-diameter rope = 3/4 inch. Use a 1-inch width of seizing.

- The seizing should be spaced a distance equal to twice the diameter of the wire rope.

Example: 2 x 3/4-inch-diameter rope = 1 1/2 inches. Space the seizing 2 inches apart.

A common method used to make a temporary wire rope seizing is as follows (fig. 6-49):

Wind the seizing wire uniformly, using tension on the wire. After making the required number of turns, as shown in step 1, twist the ends of the wires counterclockwise by hand, so the twisted portion of the wires is near the middle of the seizing, as shown in step 2.

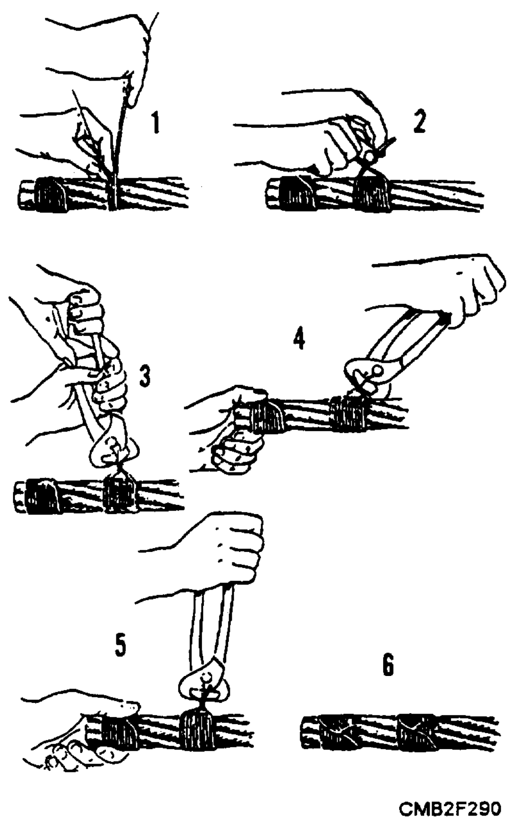

Figure 6-49.—Seizing wire rope.

Grasp the ends with end-cutting nippers and twist up slack, as shown in step 3. Do not try to tighten the seizing by twisting. Draw up on the seizing, as shown in step 4. Again twist up the slack, using the nippers as shown in step 5. Repeat steps 4 and 5 as needed. Cut the ends and pound them down on the rope, as shown in step 6. If the seizing is to be permanent, use a serving bar, or iron, to increase tension on the seizing wire when putting on the turns.

Wire rope can be cut successfully by a number of methods. An effective and simple method is to use a hydraulic type of wire rope cutter, as shown in figure 6-50. Remember that all wire should be seized before it is cut. For best results in using this method, place the rope in the cutter so the blade comes between the two central seizing. With the release valve closed, jack the blade against the rope at the location of the cut and continue to operate the cutter until the wire rope is cut.

When a hydraulic type of wire cutter is NOT available, other methods can be used. such as a hammer-type wire rope cutter (fig. 6-51), a cutting torch, and, if need be, a hacksaw and cold chisel.

Wire Rope Maintenance

Wire rope bending around hoist drums and sheaves will wear like any other metal article, so lubrication is just as important to an operating wire rope as it is to any other piece of working machinery.

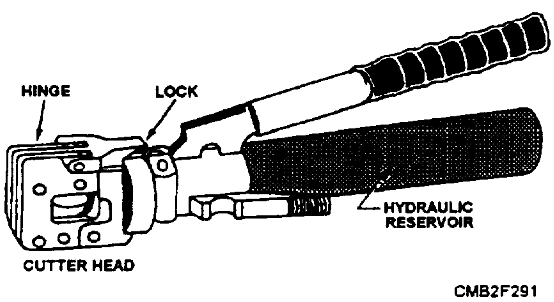

Figure 6-50.—Hydraulic type of wire cutter.

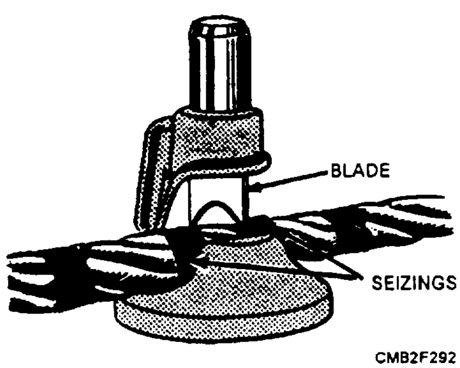

Figure 6-51.—Hammer-type wire rope cutter.

For wire rope to work right, its wires and strands must be free to move. Friction from corrosion or lack of lubrication shortens the service life of wire rope.

Deterioration from corrosion is more dangerous than that from wear because corrosion ruins the inside wires—a process hard to detect by inspection. Deterioration caused by wear can be detected by examining the outside wires of the rope, because these wires become flattened and reduced in diameter, as the wire rope wears.

NOTE

Replace wire rope that has one third of the original diameter of the outside individual wires.

Both internal and external lubrication protects a wire rope against wear and corrosion. Internal lubrication can be properly applied only when the wire rope is being manufactured, and manufacturers customarily coat every wire with a rust-inhibiting lubricant, as it is laid into the strand. The core is also lubricated in manufacturing.

Lubrication that is applied in the field is designed not only to maintain surface lubrication but also to prevent loss of internal lubrication provided by the manufacturer. The Navy issues an asphaltic petroleum oil that must be heated before using. This lubricant is known as Lubricating Oil for Chain, Wire Rope, and Exposed Gear and comes in two types:

- Type I, Regular: Does not prevent rust and is used where rust prevention is not needed; for example, elevator wires used inside are not exposed to the weather but need lubrication.
- Type II, Protective: A lubricant and an anticorrosive—it comes in three grades: grade A, for cold weather (60°F and below); grade B, for warm weather (between 60°F and 80°F); and grade C, for hot weather (80°F and above).

The oil, issued in 25-pound and 35-pound buckets and in 100-pound drums, can be applied with a stiff brush, or the wire rope can be drawn through a trough of hot lubricant (fig. 6-52). The frequency of application depends upon service conditions; as soon as the last coating has appreciably deteriorated, it should be renewed. A good lubricant to use when working in the field, as recommended by COMSECOND/COMTHRIDNCBINST 11200.11, is a mixture of new motor oil and diesel fuel at a ratio of 70-percent oil and 30-percent diesel fuel.

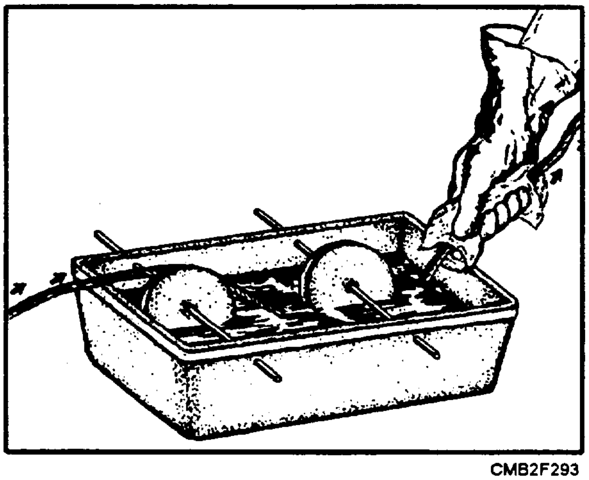

Figure 6-52.—Trough method of lubricating wire rope.

CAUTION

Avoid prolonged skin contact with oils and lubricants. Consult the Materials Safety Data Sheets (MSDS) on each item before use for precautions and hazards. See your supervisor for copies of MSDSs.

As a safety precaution, always wipe off any excess oil when lubricating wire rope especially with hoisting equipment. Too much lubricant can get into brakes or clutches and cause them to fail. While in use, the motion of machinery may sling excess oil around over cranes cabs and onto catwalks making them unsafe.

NOTE

Properly dispose of wiping rags and used or excess lubricants as hazardous waste. See your supervisor for details on local disposal requirements.

Wire Rope Attachments

Attachments are fitted to the ends of wire rope, so the rope can be connected to other wire ropes, pad eyes, or equipment. The common attachments used are the wedge socket, the speltered socket, wire rope clips, the thimble, swaged connections, and hooks and shackles.

WEDGE SOCKET.—The attachment used most often to attach dead ends of wire ropes to pad eyes or like fittings on cranes and earthmoving equipment is the wedge socket (fig. 6-53). The socket is applied to the bitter end of the wire rope.

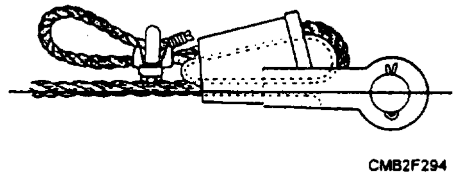

Figure 6-53.—Wedge socket.

NOTE

The wedge socket develops only 70 percent of the breaking strength of the wire rope due to the crushing action of the wedge.

SPELTERED SOCKET.—Speltering is the best way to attach a closed or open socket in the field. "Speltering" means to attach the socket to the wire rope by pouring hot zinc around it, as shown in figure 6-54. Speltering should be done by qualified personnel.

Forged steel speltered sockets are as strong as the wire rope itself. Speltered sockets are required on all cranes used to lift personnel, ammunition, acids, and other dangerous materials.

NOTE

Spelter sockets develop 100 percent of the breaking strength of the wire rope.

WIRE ROPE CLIPS.—Wire rope clips are used to make eyes in wire rope, as shown in figure 6-55. The U-shaped part of the clip with the threaded ends is called the U-bolt; the other part is called the saddle. The saddle is stamped with the diameter of the wire rope that the clip will fit. Always place a clip with the

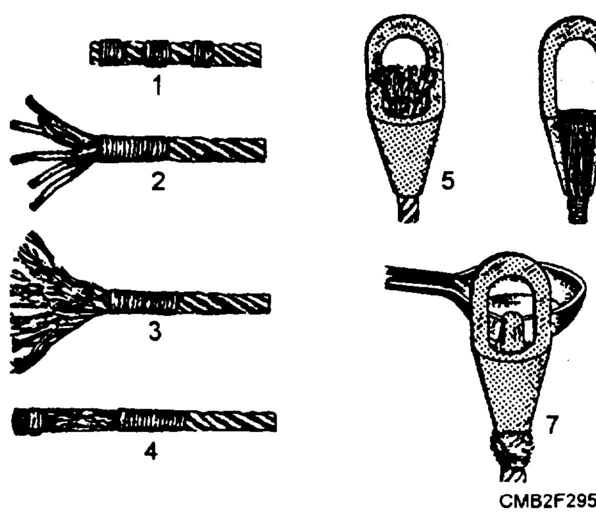

Figure 6-54.—Speltering a socket.

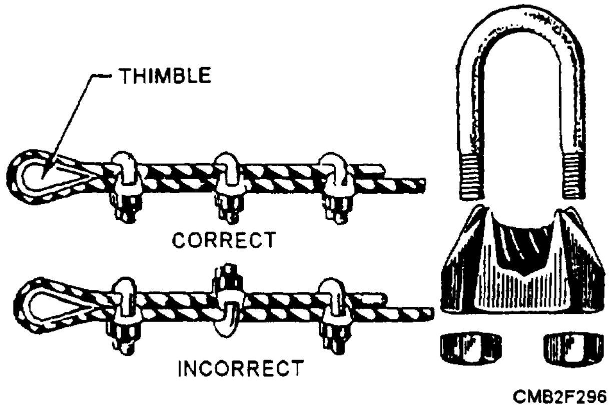

Figure 6-55.—Wire rope clips.

U-bolt on the bitter (dead) end, not on the standing part of the wire rope. If clips are attached incorrectly, the standing part (live end) of the wire rope will be distorted or have mashed spots. A rule of thumb when attaching a wire rope is to NEVER saddle a dead horse.

Two simple formulas for figuring the number of wire rope clips needed are as follows:

- 3 x wire rope diameter + 1 = Number of clips
- 6 x wire rope diameter = Spacing between clips

Another type of wire rope clip is the twin-base clip, often referred to as the universal or two clamp (fig. 6-56). Both parts of this clip are shaped to fit the wire rope, so the clip cannot be attached incorrectly. The twin-base clip allows for a clear 360-degree swing with the wrench when the nuts are being tightened.

THIMBLE.—When an eye is made in a wire rope, a metal fitting, called a thimble, is placed in the eye, as shown in figure 6-55. The thimble protects the eye against wear. Wire rope eyes with thimbles and wire rope clips can hold approximately 80 percent of the wire rope strength.

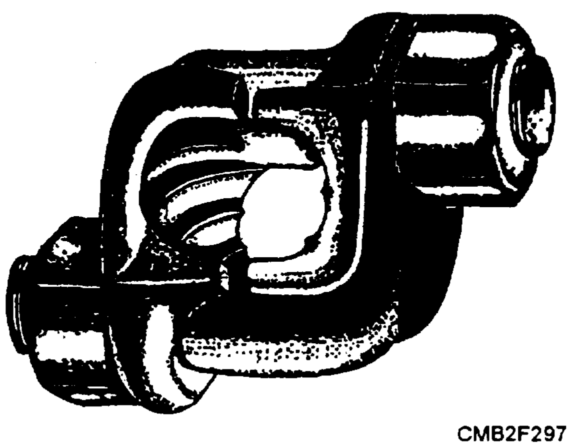

Figure 6-56.—Twin-base wire rope clip.

After the eye made with clips has been strained, the nuts on the clips must be re-tightened. Checks should be made now and then for tightness or the clips will cause damage to the rope.

SWAGED CONNECTIONS.—Swaging makes an efficient and permanent attachment for wire rope, as shown in figure 6-57. A swaged connection is made by compressing a steel sleeve over the rope by using a hydraulic press. When the connection is made properly, it provides 100 percent capacity of the wire rope.

Careful inspection of the wires leading into these connections is important because of the pressure put upon the wires in this section. If one broken wire is found at the swaged connection or a crack in the swage, replace the fitting.

HOOKS AND SHACKLES.—Hooks and shackles are handy for hauling or lifting loads without tying them directly to the object with line, wire rope, or chain. They can be attached to wire rope, fiber line, blocks, or chains. Shackles should be used for loads too heavy for hooks to handle.

When hooks fail due to overloading, they usually straighten out and lose or drop their load. When a hook has been bent by overloading, it should **NEVER** be straightened and put back into service. It should be cut in half with a cutting torch and discarded.

Hooks should be inspected at the beginning of each workday and before lifting a full-rated load. If you are not sure a hook is strong enough to lift the load, by all means use a shackle.

Hooks that close and lock should be used where there is a danger of catching *on* an obstruction, particularly in hoisting buckets, cages, or skips, and especially in shaft work. Hooks and rings used with a chain should have about the same strength as the chain.

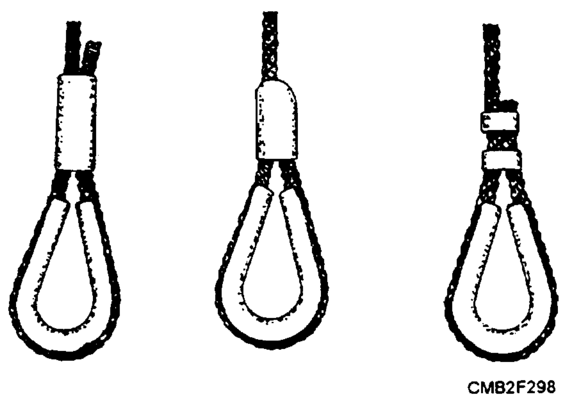

Figure 6-57.—Swaged connections.

The manufacturer's recommendations should be followed in determining the safe working loads of the various sizes and types of specific and identifiable hooks. All hooks for which no applicable manufacturer’s recommendations are available should be tested to twice the intended safe working load before they are initially put into service.

Mousing is a technique often used to close the open section of a hook to keep slings, straps, and similar attachments from slipping off the hook, as shown in figure 6-58.

Hooks may be moused with rope yarn, seizing wire, or a shackle. When using rope yam or wire, make 8 to 10 wraps around both sides of the hook. To finish off, make several turns with the yarn or wire around the sides of the mousing, and then tie the ends securely.

Two types of shackles used in rigging are the anchor (fig. 6-59) and the chain (fig. 6-60). Both are available with screw pins or round pins.

Shackles should be used in the same configuration as they were manufactured. All pins must be straight and cotter pins must be used or all screw pins must be seated. When the original pin is lost or does not fit properly, do not use the shackle. Never replace the shackle pin with a bolt.

A shackle should never be pulled from the side. This causes the shackle to bend reducing its capacity tremendously. Always attach a screw pin shackle with the screw pin on the dead end of the rope. If placed on the running end, the movement of the rope may loosen the pin.

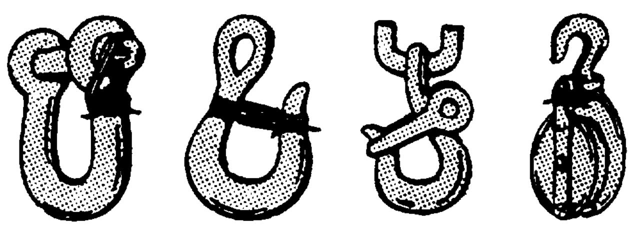

Figure 6-58.—Mousing.

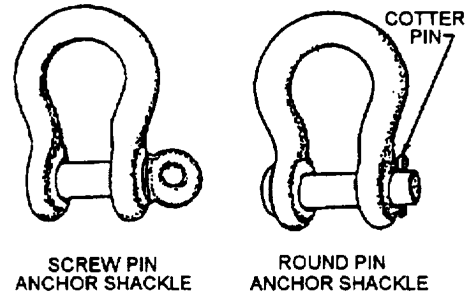

Figure 6-59.—Anchor shackles.

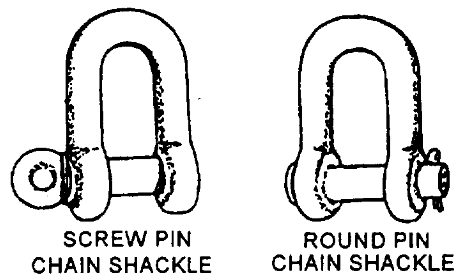

Figure 6-60.—Chain shackles.

Shackles are moused whenever there is a chance of the shackle pin working loose and coming out due to vibration. To mouse a shackle, simply take several turns with seizing wire through the eye of the pin and around the bow of the shackle. Refer to figure 6-58 for proper mousing.

REVIEW 3 QUESTIONS

Q1. What are the two types of brakes used on a jaw-clutch type winch?

Q2. What device is used on a winch to prevent crushing of the cable due to loose crossed coils and layers?

Q3. Wire rope is composed of what total number of parts?

Q4. What is the most common type of wire rope used by the NCF?

Q5. What is the recommended ratio of new oil to diesel for the lubrication of wire rope?

REVIEW 1 ANSWERS

Q1. *Two forward and two reverse speeds*

Q2. *Forward clutch shaft*

Q3. *Pump-motor team*

Q4. *Charge pump*

Q5. *Variable displacement*

REVIEW 2 ANSWERS

Q1. *Pins and bushings*

Q2. *Ruler and tape measure*

Q3. *Grouser*

Q4. *Front idler*

Q5. *Rear guiding guards*

REVIEW 3 ANSWERS

Q1. *Worm shaft brake and shifter bracket brake*

Q2. *Automatic level winding device*

Q3. *Three*

Q4. *Improved plow steel wire rope*

Q5. *70 percent new oil to 30 percent diesel*